Rockchip Linux Power Load Test

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Trademark Statement

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Preface

Overview

This document mainly introduces the ways and steps of testing and optimizing power consumption of Rockchip Linux platform, aiming to help engineers lean basic troubleshooting steps, and optimize, and debug power consumption issues. And achieve reasonable system performance and power consumption, and increasing security.

Intended Audience

This document (this guide) is mainly intended for:

Technical support engineers

Software development engineers

Product Version

Chipset	Buildroot	Debian 9
RK3399	Y	Y

Revision History

Date	Version	Author	Change Description
2020-09-14	V1.0.0	Caesar Wang	Initial version
2021-11-08	V1.0.1	Ruby Zhang	Update some expressions

Contents

1. System Power Consumption Analysis

The key test conditions of RK3399 are as follows:

- CPU: 4xA53+2xA72, frequency up to 1.8GHz
- DDR: Maximum frequency is 856MHz
- GPU: Maximum frequency is 800MHz

The following mainly introduces the power consumption data of static desktop, video playback, stress test and deep sleep in the Buidroot or Debian9 Linux system.

1.1 Buildroot System Power Consumption in Different Scenarios

Test items	Buildroot: RK_IND_EVB_RK3399_LP4D200P232SD8_V11_20190905 (Sample:41810 693 Sample/S 00:01:00)																	
	VCC SOC	VCC12V DCIN		VDD CPU B		VDD GPU		VDD LOG		VDD CENTER		VDD CPU L		VCC DDR		VCC3V3 SYS		
	Power consumption (mW)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	
Static desktop (with a screen)	1982.4726	11.932	907.6	0.856	16.5	0.862	60.5	0.96	276	0.924	531.7	0.832	18.5	1.088	58.1	3.26	331.7	
Static desktop (without a screen)	1876.9895	12.02	708.9	0.853	14.8	0.86	57.5	0.963	227.6	0.921	496.8	0.829	10.2	1.091	57.2	3.259	327.5	
1080p Transformers 3	2340.035	11.89	997.5	0.857	20.7	0.862	187.4	0.959	297.1	0.929	739.1	0.841	54.3	1.08	58.8	3.261	331.2	
4K@30fps Birds	2392.5669	11.881	1019.6	0.858	20.5	0.863	137.6	0.959	304.9	0.932	815.8	0.845	68.4	1.078	58.8	3.26	332	
Glmark2 test	2410.0431	11.887	1007.9	0.86	67.3	0.887	225.4	0.953	351	0.926	593.7	0.834	47.8	1.08	58.4	3.257	357.7	
Stress test	4126.4532	11.736	1340	0.912	764.9	1.081	191.1	0.948	438.4	0.935	818.7	1.125	783.1	1.063	60.7	3.26	336.1	
Deep sleep test	120.5585	12.325	22.1	0	0	0	0	0.979	35.1	0	0	0	0	1.093	53.6	3.287	8.4	

From the above data, we can see that:
The power consumption with a screen is Pd=2.3W, the power consumption of a static desktop is Pui=10.8W, the power consumption of 1080P video is Pl= 11.86W, the power consumption of 4K@30fps video is Pb=12.1W, and the power consumption of graphics stress test glmark2 is Pg= 11.98W, the power consumption of system stress test is Ps=15.72W.

- The power consumption of a static desktop on the Soc side is Psui=1.88W
- The power consumption of 1080P video on the Soc side is Psl=2.34W
- The power consumption of 4K video on the Soc side is Psb=2.39W
- The power consumption of Glmark2 on the Soc side is Psg=2.41W
- The power consumption of stress test on the Soc side is Pss=4.13W
- The power consumption in deep sleep mode on the Soc side is Ps2=120.5mW

1.2 Debian 9 System Power Consumption in Different Scenarios

Test items	Debian9: RK_IND_EVB_RK3399_LP4D200P232SD8_V11_20190905 (Sample:41810 693 Sample/S 00:01:00																
	VCC SOC	VCC12V DCIN		VDD CPU B		VDD GPU		VDD LOG		VDD CENTER		VDD CPU L		VCC DDR		VCC3V3 SYS	
	Power consumption (mW)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)
Static desktop (with a screen)	1966.9842	11.927	909.3	0.856	15	0.866	52.3	0.961	270.7	0.924	525.7	0.833	14	1.088	59.2	3.261	333.3
Static desktop (without a screen)	1894.8035	12.021	700.9	0.853	17	0.863	55.6	0.963	228.7	0.921	499.8	0.83	15.1	1.09	57.9	3.259	330.2
1080p Transformers 3	2231.3292	11.907	959.9	0.857	18.3	0.864	61.1	0.952	356.5	0.927	701.5	0.832	25.6	1.085	58.4	3.26	333.9
4K@30fps Birds	2381.1659	11.887	1006.8	0.857	25.8	0.864	66	0.951	356.7	0.931	815.8	0.836	32.7	1.078	58.4	3.259	338.6
Glmark2 test	2342.1851	11.887	1006.8	0.866	84.7	0.954	231	0.953	351.2	0.926	591.4	0.833	19.6	1.083	58.7	3.26	333.2
Stress test	4057.176	11.729	1360	1.01	805.7	0.867	147.5	0.948	445.5	0.938	814.4	1.123	693.5	1.057	60	3.261	336.8
Deep sleep test	111.6261	12.325	20.9	0	0	0	0	0.979	32.3	0	0	0	0	1.094	53.3	3.287	6.6

From the above data, we can see that:
The power consumption with a screen is Pd=2.4W, the power consumption of a static desktop is Pui=10.84W, the power consumption of 1080P video is Pl=11.43W, the power consumption of 4K@30fps video is Pb=11.96W, and the power consumption of graphics stress test glmark2 is Pg=11.97W, the power consumption of system stress test is Ps=15.95W.

- The power consumption of a static desktop on the Soc side is Psui=1.89W
- The power consumption of 1080P video on the Soc side is Psl=2.23W
- The power consumption of 4K video on the Socside is Psb=2.38W
- The power consumption of Glmark2 on the Soc side is Psg=2.34W
- The power consumption of stress test on the Soc side is Pss=4.06W
- The power consumption in deep sleep mode on the Soc side is Ps2=111.6mW

2. System Power Optimization

2.1 Basic Troubleshooting Steps for Power Consumption

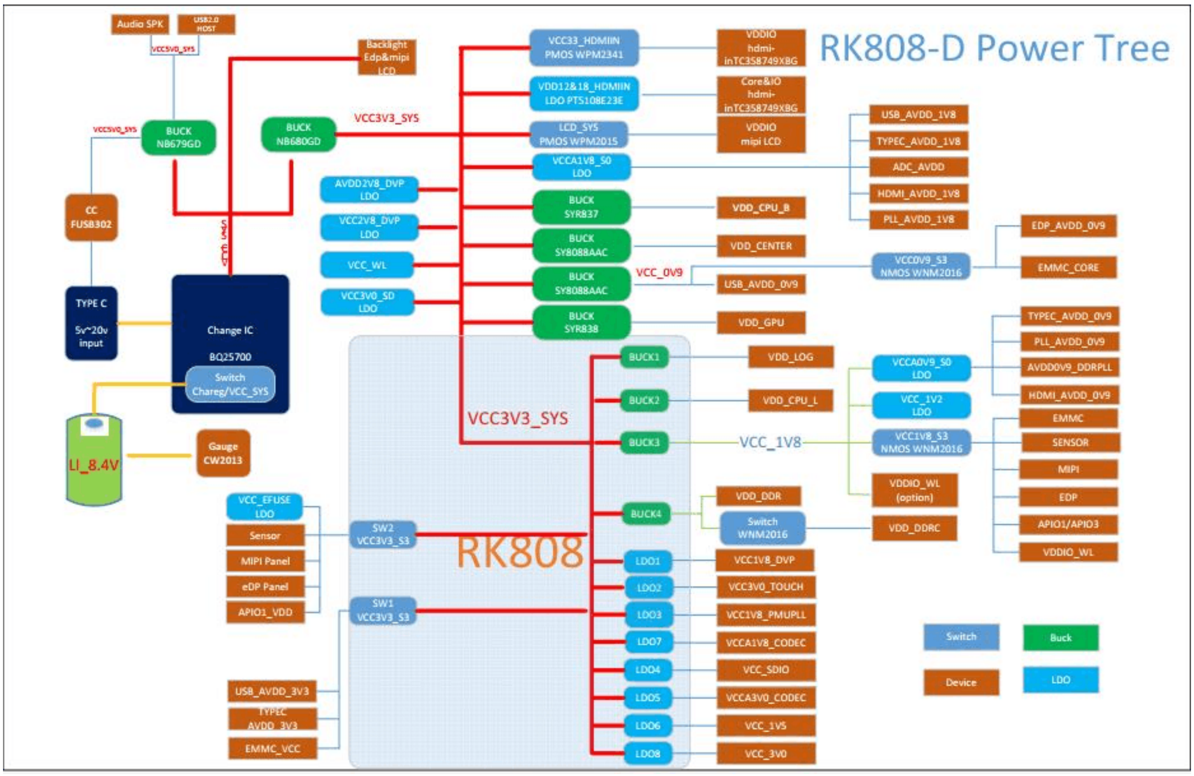
2.1.1 Total Power Consumption Comparison

First, compare the total power consumption in the same scenario to check whether the board power consumption is normal firstly. Refer to the total power consumption data of various scenarios in the above chapters. If there is a big difference between the total power consumption of a customer board and the SDK board reference data provided by RK, it is recommended to further analyse the power consumption.

Note: When testing power consumption data, make sure that there are only differences between hardwares and other test conditions should be the same. For example, comparing the power consumption data of 1080P/4K video playback scenarios, requiring the same video source, removing the edp screen and hdmi display, and so on.

2.1.2 Power Consumption of Each Channel Analysing

In order to analyse the power consumption of each channel in details, it is also necessary to be familiar with the project Power Tree. The picture below is the RK3399 excavator Power Tree. In the process of optimizing the power consumption of the project, you can list the Power Tree according to the hardware schematic diagram, and then connected a resistor in series with a certain resistance on the corresponding circuit (generally recommend a 20mR resistor in series) to measure the current of the corresponding circuit. RK3399 excavator power consumption is divided into the following parts: VCC3V3_SYS, VDD_CPU_B, VDD_CPU_L, VDD_GPU, VDD_LOG, VDD_0V9, VDD_CENTER, VCC_DDR, VCC_1V8.



Compare the data after dividing the power consumption. Firstly, compare whether the power consumption of the CPU core, GPU, and DDR is normal, and confirm whether the CPU frequency conversion, GPU frequency conversion, and DDR frequency conversion are normal. If there is a increasing voltage, confirm whether the increasing voltage is an integer times of 12.5mv. When the frequency conversion strategy is normal, it is necessary to further compare and analyze the power consumption of other peripherals.

2.1.3 Clock Checking

Check the clock status of each subsystem, you will see the relationship between clock frequency, enable_count, prepare_count, parent-child clock, etc. The commonly used clock commands are as follows (take saradc as an example):
The command to search the Clock Tree:

```
# Get the total Clock status:
cat /sys/kernel/debug//clk/clk_summary

# Setting frequency (unit HZ):
echo 24000000 > /sys/kernel/debug/clk_saradc/clk_rate

# Get frequency
cat /sys/kernel/debug/clk_saradc/clk_rate

# Open clock:
echo 1 > /sys/kernel/debug/clk_saradc/clk_enable_count

# Colse clock:
echo 0 > /sys/kernel/debug/clk_saradc/clk_enable_count
```

Note: The reference count enable_count means that the reference count (clk_enable) will be +1 after the driver actively applies for enabling the clock. However, there are some clocks that are always on by default, and the reference count may be 1 or 0, there is no need to care too much about these clocks when checking power consumption. The main concern is whether the enable_cnt of the CLK of the unused device is 0. If it is not 0, you can manually turn off the CLK command to turn off debugging.

2.1.4 Power Domain (PD) Checking

Make sure the current status of each PD. If the module is not in use, and its status is suspend, then after all the devices under the PD are suspend, the PD will be closed, as follows:

The command to search the PD summary:

```
 # cat /sys/kernel/debug/pm_genpd/pm_genpd_summary
domain                          status          slaves
    /device                                             runtime status
----------------------------------------------------------------------
pd_vopl                         on
    /devices/platform/ff8f3f00.iommu                    active
    /devices/platform/ff8f0000.vop                      active
pd_vopb                         off
    /devices/platform/ff903f00.iommu                    suspended
    /devices/platform/ff900000.vop                      suspended
pd_vo                           on              pd_vopb, pd_vopl
pd_tcpc1                        on
    /devices/platform/ff800000.phy                      active
pd_tcpc0                        on
    /devices/platform/ff7c0000.phy                      active
pd_isp1                         on
    /devices/platform/ff924000.iommu                    active
    /devices/platform/ff920000.rkisp1                   suspended
pd_isp0                         on
    /devices/platform/ff914000.iommu                    active
    /devices/platform/ff910000.rkisp1                   suspended
pd_hdcp                         on
    /devices/platform/ff940000.hdmi                     active
```

DTS configuration (take VOPB as an example):

```
vopb: vop@ff900000 {
    power-domains = <&power RK3399_PD_VOPB>;
};
```

Note: If a PD is not referenced in the DTS node, this PD is considered to be not used by devices and will be closed by the framework after booting. If a PD reference is added to the above DTS node, but the vop driver has no runtime operation, this PD is always open (because the device is considered to be an unsupported runtime, the status will become unsupported). If a PD reference is added to the DTS node, and there is also a runtime operation in the driver, then the status of the PD depends on whether the driver actively applies for on or off. Summary of reducing operating power consumption: Query pd summary and clk tree, and PD and CLK of unused modules need to be turned off to avoid leakage of internal MOS tubes.

2.2 Basic Optimization Steps for Power Consumption

2.2.1 Modify the Default Backlight Value

[root@rk3399:/]# cat /sys/class/backlight/backlight/brightness
200

There are 0-255 values that can be set by default, the brighter the lighter, it can be set to 100,

echo 100> /sys/class/backlight/backlight/brightness

Of course, it can be reduced according to actual situations.

2.2.2 Reduce Refresh Rate

With practical instance, the actual GPU refresh rate is only below 30fps, you can change the refresh rate of dsi:

```
native-mode = <&mipi_1280x800>;
mipi_1280x800: mipi-1280x800 {
-clock-frequency = <76000000>;
+ clock-frequency = <60000000>;//45fps
hactive = <800>;
vactive = <1280>;
hsync-len = <10>;
```

2.2.3 Colse ISP

Turn off some unused modules in dts, if it is a USB camera, you can turn off ISP:

```
+&isp0 {
+        status = "disabled";
+};
+
+&isp1 {
+        status = "disabled";
+};
+
+&isp0_mmu {
+        status = "disabled";
+};
+
+&isp1_mmu {
+        status = "disabled";
+};
```

2.2.4 Modify Frequency Adjustment Strategy

```
--- a/arch/arm64/boot/dts/rockchip/rk3399-opp.dtsi
+++ b/arch/arm64/boot/dts/rockchip/rk3399-opp.dtsi
@@ -50,6 +50,8 @@
                rockchip,temp-hysteresis = <5000>;
                rockchip,low-temp = <10000>;
                rockchip,low-temp-min-volt = <900000>;
+               rockchip,high-temp = <45000>;
+               rockchip,high-temp-max-volt = <1000000>;

                nvmem-cells = <&cpul_leakage>, <&specification_serial_number>;
                nvmem-cell-names = "cpu_leakage",
@@ -141,6 +143,8 @@
                rockchip,temp-hysteresis = <5000>;
                rockchip,low-temp = <10000>;
                rockchip,low-temp-min-volt = <900000>;
+               rockchip,high-temp = <45000>;
+               rockchip,high-temp-max-volt = <1025000>;
                nvmem-cells = <&cpub_leakage>, <&specification_serial_number>;
                nvmem-cell-names = "cpu_leakage",
```

2.2.5 Adjust Target Load

The default load is 90:

```
[root@rk3399:/sys/devices/system/cpu/cpufreq/policy4/interactive]# cat
target_loads
90
```

It can be modified to:

```
[root@rk3399:/sys/devices/system/cpu/cpufreq/policy4/interactive]# cat
target_loads
65 1008000:70 1200000:75 1416000:80 1608000:90
```