Freescale Semiconductor
Application Note

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i.MX35 Multimedia Power Consumption Under Linux

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This document describes the considerations for measuring the current consumption of the i.MX35 System on a Chip (SOC) in an embedded application under the Linux operating system.

This guide is intended for users of the i.MX35 SOC in power sensitive applications where the Linux operating system is to be used.

For more information about GStreamer visit http://gstreamer.freedesktop.org/.

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1 Overview

This application note presents a method for characterizing the real-time power consumption of the i.MX35 processor using the i.MX35 Product Development Kit (PDK) with the Linux operating system.

1.1 Method

To measure the power consumption of the i.MX35, various power supply voltages and currents are measured for the i.MX35 during operation. Power consumption is calculated by summing the product of the voltage and current for each power supply.

1.2 Test Setup

A pre-production i.MX35 PDK, also known as the i.MX35 3-Stack, was used as the measurement platform for this application note. The version 1.1.2 CPU card had a production i.MX35 device on it, marked PCIMX356AVM4B.

Four power supply series resistors for the Core, CPU IO, PLL and DDR supplies were removed from the CPU card. Connection points were added to the resistor pads to allow the connection of external ammeters in place of the 0.02 Ω series resistors. The schematic identifiers for the pre-production board for these resistors are not given here. The corresponding resistor identifiers for the production CPU card are:

- R228 — Core
- R229 — CPU IO
- R270 — PLL
- R218 — DDR

The current for each of these four supplies was measured by connecting four bench ammeters to the CPU card across the series resistor pads, one for each power supply. The voltage for each supply was measured at the ammeter on the i.MX side. Figure 1 shows the connection diagram of a single ammeter and voltmeter to series power supply resistor Rxx on the CPU card.

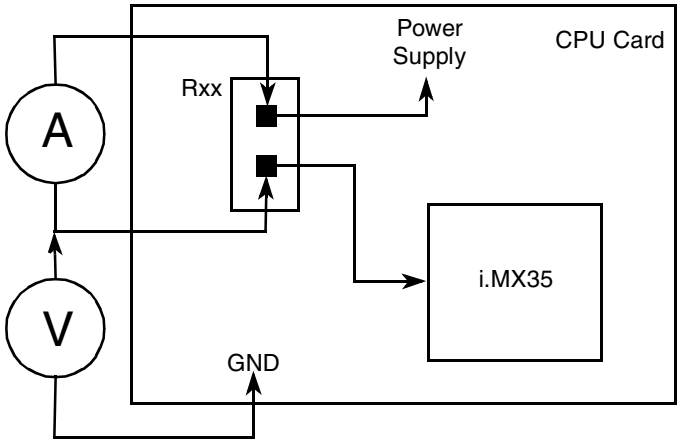

Figure 1. Power Measurement Connection Diagram

1.3 Current Measurement Details

The use of multiple bench ammeters in place of the 0.02 Ω series resistors was chosen as the method for this application note.

The design of the CPU card precluded separating out only the i.MX35 contribution to the DDR power supply; therefore, there was no way to split the i.MX35 from the rest of the circuitry in the bus without a layout change. As such, the DDR power consumption necessarily includes the contribution of four DDR2 memories (K4T51163QE-ZID5), two 74VCX163245MTD and one 74LVC4245APW in addition to the i.MX35.

1.4 Software and OS

The scope of the power measurements for this application note is limited to multimedia codecs playing or converting media files under the Linux operating system. The Linux kernel and root file system were built from the internal source archive: 20090330_L2.6.26_4.0.0_MX37TO1.1.1_AV_ER6_sp_ww12_2009. This particular source archive contained all the GStreamer codecs used. The root file system was built as a JFFS2 file system. The build environment was Ubuntu 8.10 and had all current updates applied at the time. The kernel and rootfs were loaded into the NAND flash of the PDK via the Freescale's Advanced ToolKit version 1.66.

1.5 Media

The format details of the various audio and multimedia files used in this application note are contained in Appendix A, “Media File Information.” The media files were played or converted using GStreamer, an open-source multimedia framework under which the Freescale-optimized codecs are used as plugins. The specific command lines for GStreamer used in this application note are in Appendix B, “GStreamer Command Lines.”

1.6 Data Collection

For each media file/codec, the supply current of each power supply was monitored, visually averaged and then recorded along with the corresponding supply voltage. The measurements were conducted with the i.MX35 core running at 400 MHz and 532 MHz.

2 Results

Table 1 contains the calculated and summarized average power consumption of the i.MX35 for various media files under Linux. All the raw current and voltage measurements are contained in Appendix C, “Raw Data.” The power consumption is the summation of the calculated power of each power supply (the product of the voltage and current measured for that supply).

Although as many as three significant figures appear to be presented in Table 1, the values should not be considered as having more than two significant figures because of the visual averaging of the current during the measurements.

Table 1. Multimedia Average Power Consumption Summary

Media Type	532 MHz (mW)[1]	400 MHz (mW)	Delta @ 532 MHz (mW)	Delta @ 400 MHz (mW)	Difference (mW)
MP3 Playback	315	297	31	29	1.8
WAV Playback	313	298	29	30	0.3
AAC+ SBR Playback	338	319	54	50	3.9
WMA Playback	315	298	31	30	1.5
WMA Pro Playback	322	300	38	32	5.7
WMA Lossless Playback	370	345	86	77	9.5
WMV/ASF Playback	455	424	171	156	15.7
MP4 (MPEG4+MP3) Playback	418	391	135	123	12.0
AVI (MPEG4+MP3) Playback	418	392	135	124	10.5
MP3 Record (File to File)	582	492	298	224	74.5
Idle (Nothing Running)	284	268	—	—	—
Peak Power by Simulation[2]	1312	—	—	—	—

[1] DDR component is a combination of i.MX35 contribution plus all other 1.8 V devices (4xDDR2 (K4T51163QE-ZID5), 2x74VCX163245MTD, 1x74LVC4245APW).

[2] The peak power is the summation of the maximum power by simulation for the individual modules of the i.MX35 at 532 MHz, which are tabulated in Appendix D, “Peak Power Data.”

The first two columns in Table 1 show the total power consumption of the i.MX35 for the four power supplies measured. Although the actual contribution of the i.MX35 is lower than this number because the layout of the CPU card precluded separating the i.MX35 from the other devices on that power supply rail, the relative proportion of contribution to power is assumed to be constant. The second two columns are difference between the power consumption calculated for each codec and the idle current when no codec was active for each corresponding core frequency. Idle was considered to be the state when nothing from the command line was executing and only the normal processes that regularly run in the background were active. The last column is the absolute value of the difference between the delta measurements.

As would be expected, current consumption increases as a function of core frequency. In looking at the difference column and the fact that only two significant figures should be considered, the contribution to power consumption by all the codecs except MP3 recording is essentially the same (no difference is greater than ~16 mW). The difference with MP3 recording is that it is not constrained to real-time output of audio and/or video like the other codecs; all the other media played at normal real-time rates.

The last row in Table 1 is the maximum power consumption for the i.MX35 at 532 MHz, which is the summation of the maximum consumption for each module in the i.MX35.

Appendix A Media File Information

Table 2 contains the information for each media file used in the collection of the data for this application note. The actual file names of the media files have been omitted.

Table 2. Media File Information

Media File	Information
MP3 Input File	MPEG Layer 3, Stereo, 44.1 KHz, 160 Kbits/sec
MP3 Output File	MPEG Layer 3, Stereo, 44.1 KHz, 128 Kbits/sec (output of MP3 record)
WAV File	16-bit integer (little endian), Stereo, 44.1 KHz, 1.41 Mbits/sec, 16-bits/sample
WMV/ASF File	Audio: WMA2 codec, Stereo, 44.1 KHz, 48 Kbits/sec, 16-bits/sample Video: WMV1 codec, 320x240 resolution
MP4 File	Audio: MPGA codec, Stereo, 44.1 KHz, 1411 Kbits/sec, 16-bits/sample Video: MP4V codec, 320x240 resolution, 29.97 fps
AVI File	Audio: MPGA codec, Stereo, 12 KHz, 160 Kbits/sec Video: MP4V codec, 320x240 resolution, 30.00 fps
WMA Pro File	WMAP codec, Stereo, 48 KHz, 128 Kbits/sec, 16-bits/sample
WMA Lossless File	WMAL codec, Stereo, 48 KHz, 1152 Kbits/sec, 24-bits/sample
WMA File	WMA2 codec, Stereo, 48 KHz, 192 Kbits/sec, 16-bits/sample
AAC SBR File	MP4A codec, Stereo, 44.1 KHz, AAC extensions SBR+PS

Appendix B GStreamer Command Lines

Below are the GStreamer command lines and pipes used to play each media file type. The actual file names used have been omitted.

MP3 Playback
```
gst-launch filesrc location=filename.mp3 ! mfw_mp3decoder ! alsasink
```

WAV Playback
```
gst-launch filesrc location=filename.wav ! wavparse ! alsasink
```

WMV/ASF Playback
```
gst-launch filesrc location=filename.wmv ! mfw_asfdemuxer
name=demux demux. ! queue max-size-buffers=0 ! mfw_wmvdecoder
! mfw_v4lsink demux. ! queue max-size-buffers=0 !
mfw_wma10decoder ! alsasink
```

AAC+SBR Playback
```
gst-launch filesrc location=filename.aac ! mfw_aacdecoder ! alsasink
```

WMA Playback
```
gst-launch filesrc location=filename.wma ! mfw_asfdemuxer !
mfw_wma10decoder ! alsasink
```

WMA Pro Playback
```
gst-launch filesrc location=filename.wma ! mfw_asfdemuxer !
mfw_wma10decoder ! alsasink
```

WMA Lossless Playback
```
gst-launch filesrc location=filename.wma ! mfw_asfdemuxer !
mfw_wma10decoder ! alsasink
```

MP4 (MPEG4+MP3) Playback
```
gst-launch filesrc location=filename.mp4 ! mfw_mp4demuxer
name=demux demux. ! queue max-size-buffers=0 !
mfw_mpeg4decoder ! mfw_v4lsink demux. ! queue max-size-buffers=0
! mfw_mp3decoder ! alsasink
```

AVI (MPEG4+MP3) Playback
```
gst-launch filesrc location=filename.avi ! mfw_avidemuxer
name=demux demux. ! queue max-size-buffers=0 !
```

	mfw_mpeg4decoder ! mfw_v4lsink demux. ! queue max-size-buffers=0 ! mfw_mp3decoder ! alsasink
MP3 Record (File to File)	gst-launch filesrc location=filename.wav ! wavparse ! mfw_mp3encoder ! filesink location=output.mp3

Appendix C Raw Data

The raw voltage and current data for each media file, power supply, and core frequency is shown in Table 3.

Table 3. Raw Data

Media Type	Power Supply	532 MHz				400 MHz			
		Voltage (V)	Current (MA)	Power (mW)	Total (mW)	Voltage (V)	Current (MA)	Power (mW)	Total (mW)
MP3 Playback	Core	1.33	80	106	315	1.22	73	89	297
	DDR[1]	1.8	79	145		1.8	79	145	
	CPU IO	3.3	12.3	40		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
WAV Playback	Core	1.33	80	106	313	1.22	75	92	298
	DDR[1]	1.8	78	143		1.8	78	143	
	CPU IO	3.3	12.4	41		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
WMV/ASF Playback	Core	1.33	140	186	455	1.22	130	159	424
	DDR[1]	1.8	110	201		1.8	108	198	
	CPU IO	3.3	13.5	44		3.3	13.6	45	
	PLL	1.4	16.2	23		1.4	16.1	23	
AAC+ SBR Playback	Core	1.33	96	128	338	1.22	89	109	319
	DDR[1]	1.8	80	146		1.8	80	146	
	CPU IO	3.3	12.4	41		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
WMA Playback	Core	1.33	80	106	315	1.22	75	92	298
	DDR[1]	1.8	79	145		1.8	78	143	
	CPU IO	3.3	12.4	41		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	

Table 3. Raw Data (continued)

Media Type	Power Supply	532 MHz				400 MHz			
		Voltage (V)	Current (MA)	Power (mW)	Total (mW)	Voltage (V)	Current (MA)	Power (mW)	Total (mW)
WMA Pro Playback	Core	1.33	85	113	322	1.22	77	94	300
	DDR[1]	1.8	79	145		1.8	78	143	
	CPU IO	3.3	12.4	41		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
WMA Lossless Playback	Core	1.33	120	160	370	1.22	112	137	345
	DDR[1]	1.8	80	146		1.8	79	145	
	CPU IO	3.3	12.4	41		3.3	12.4	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
MP4 (MPEG4+MP3) Playback	Core	1.33	120	160	418	1.22	110	134	391
	DDR[1]	1.8	105	192		1.8	104	190	
	CPU IO	3.3	13.2	43		3.3	13.2	43	
	PLL	1.4	16.2	23		1.4	16.1	23	
AVI (MPEG4+MP3) Playback	Core	1.33	120	160	418	1.22	110	134	392
	DDR[1]	1.8	105	192		1.8	105	192	
	CPU IO	3.3	13.2	43		3.3	13.1	43	
	PLL	1.4	16.2	23		1.4	16.1	23	
MP3 Record (File to File)	Core	1.33	245	326	582	1.22	201	245	492
	DDR[1]	1.8	105	192		1.8	100	183	
	CPU IO	3.3	12.5	41		3.3	12.5	41	
	PLL	1.4	16.2	23		1.4	16.1	23	
Idle (Nothing Running)	Core	1.33	61	81	284	1.22	54	66	268
	DDR[1]	1.8	76	139		1.8	76	139	
	CPU IO	3.3	12.3	40		3.3	12.3	40	
	PLL	1.4	16.2	23		1.4	16.1	23	

[1] DDR current is a combination of i.MX35 contribution plus all other 1.8 V devices (4xDDR2 (K4T51163QE-ZID5), 2x74VCX163245MTD, 1x74LVC4245APW).

Appendix D Peak Power Data

Table 4 shows the peak power numbers for the i.MX35 under worst case voltage and temperature conditions. These values are derived from the i.MX35 with core clock speeds up to 532 MHz. Common supplies have been bundled according to Freescale's power-up sequence requirements. Peak numbers are provided for system designers so that the i.MX35 power supply requirements are satisfied during startup

and transient conditions. Freescale recommends that system current measurements be taken with customer-specific use-cases to reflect normal operating conditions in the end system.

Table 4. Peak Power Data

Supply	Voltage (V)	Peak Current (mA)	Peak Power (mW)
QVCC	1.47	400	588
MVDD_PVDD	1.65	20	33
NVCC_EMI1 NVCC_EMI2 NVCC_EMI3 NVCC_LCDC NVCC_NFC	1.9	90	171
FUSE_VDD[1]	3.6	62	223
NVCC_MISC NVCC_CSI NVCC_SDIO NVCC_CRM NVCC_ATA NVCC_MLB NVCC_JTAG	3.6	60	216
OSC24M_VDD OSC_AUDIO_VDD PHY1_VDDA PHY2_VDD USBPHY1_UPLLVDD USBPHY1_VDDA_BIAS	3.6	25	90
Total	—	—	1321

[1] This rail is typically tied to ground, it only needs a voltage if in-system fuse burning is needed.

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