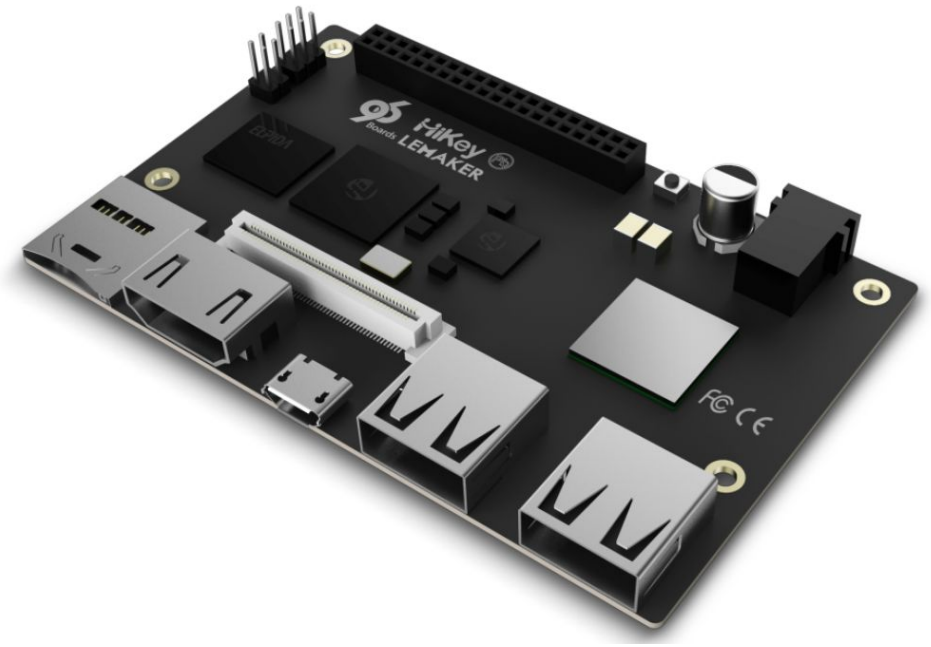
HiKey (LeMaker version) Hardware User Manual

Version 0.1, December 2015



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Introduction

The HiKey board is the first board to be certified 96Boards Consumer Edition compatible, and it's based around the HiSilicon Kirin 620 (also called Hi6220) SoC, with eight-core ARM Cortex-A53 64-bit CPU up to 1.2GHz .

The following table lists its key features:

Processor	HiSilicon Kirin 620 SoC Integrated octa-core 64-bit ARM Cortex-A53 CPU up to 1.2 GHz per core Embedded Mali450-MP4 GPU, supporting 3D graphics processing, OpenGL ES 1.1/2.0,OpenVG 1.1, 2000Mega@500 MHz, 110M triangle@500 MHz, and 32G flops@500MHz
Memory/ Storage	1GB/2GB 800MHz LPDDR3 8GB eMMC on-board storage
Video	Embedded video hardware encoder, supporting 1080p@30 fps HD camera Embedded video hardware decoder, supporting 1080p@30 fps HD video decoding in the following formats: H.264, SVC, MPEG1/2/4, H.263, VC-1, WMV9, DivX, RV8/9/10,AVS
Camera Support	One 4-lane MIPI camera serial interface (CSI), one 2-lane MIPI CSI
Audio	WMA/MP3/AAC/EVS audio encoding and decoding
Connectivity	WLAN 802.11 b/g/n 2.4GHz Bluetooth 4.0 LE One USB 2.0 micro B (device mode only) Two USB 2.0 (host mode only) HDMI
I/O Interfaces	**40 pin low speed expansion connector:** +1.8V, +5V, SYS_DCIN, GND, UART, I2C, SPI, PCM, PWM,GPIO x12 **60 pin high speed expansion connector:** SDIO, MIPI_DSI, MIPI_CSI, I2C , USB2.0
External Storage	Micro SD card slot
User Interface	Power/Reset 1 WiFi activity LED(Yellow) 1 BT activity LED (Blue)

	4 User LEDs (Green)
OS-support	Android 6.0 Linux based on Debian
Power, Mechanical and Environmental	Power: 8V-18V@2A input Dimensions: 54mm by 85mm meeting 96Boards™ Consumer Edition standard dimensions specifications. Operating Temp: 0°C to +70°C

Change History

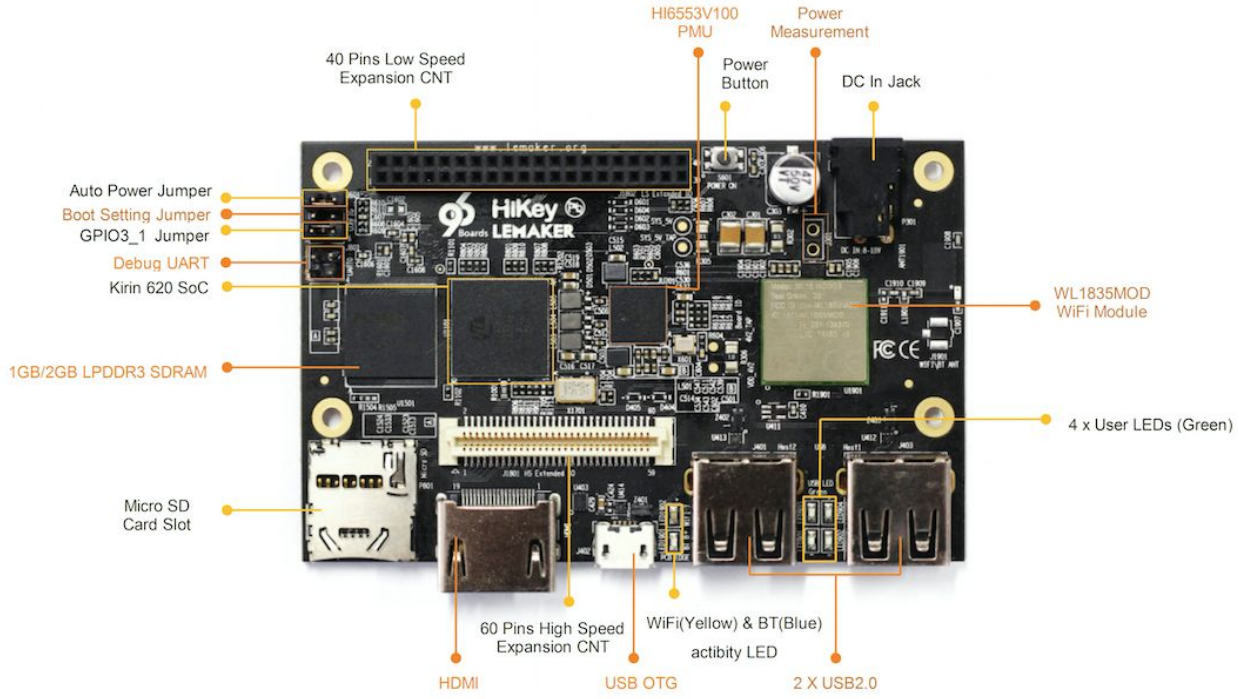
Version	Changed By	Description of Changes
0.0	Oldpan	Initial version of HiKey (LeMaker version)
0.1	Tony Zhang	Use the latest 96Boards hardware manual template and fix some problem from the reviewers.

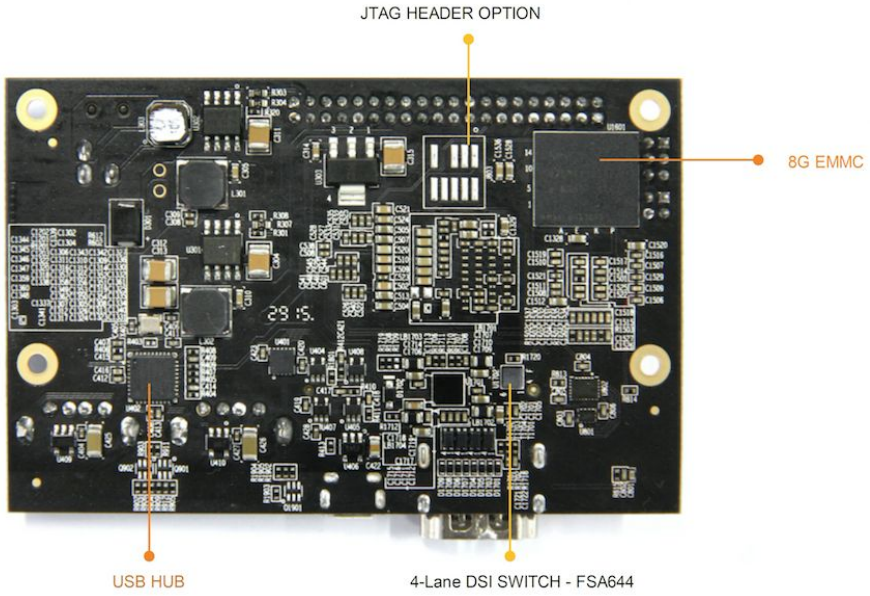
What's in the Box

The box contains a HiKey board, a power supply adapter cable, a product instruction manual and a statement for GPU library.

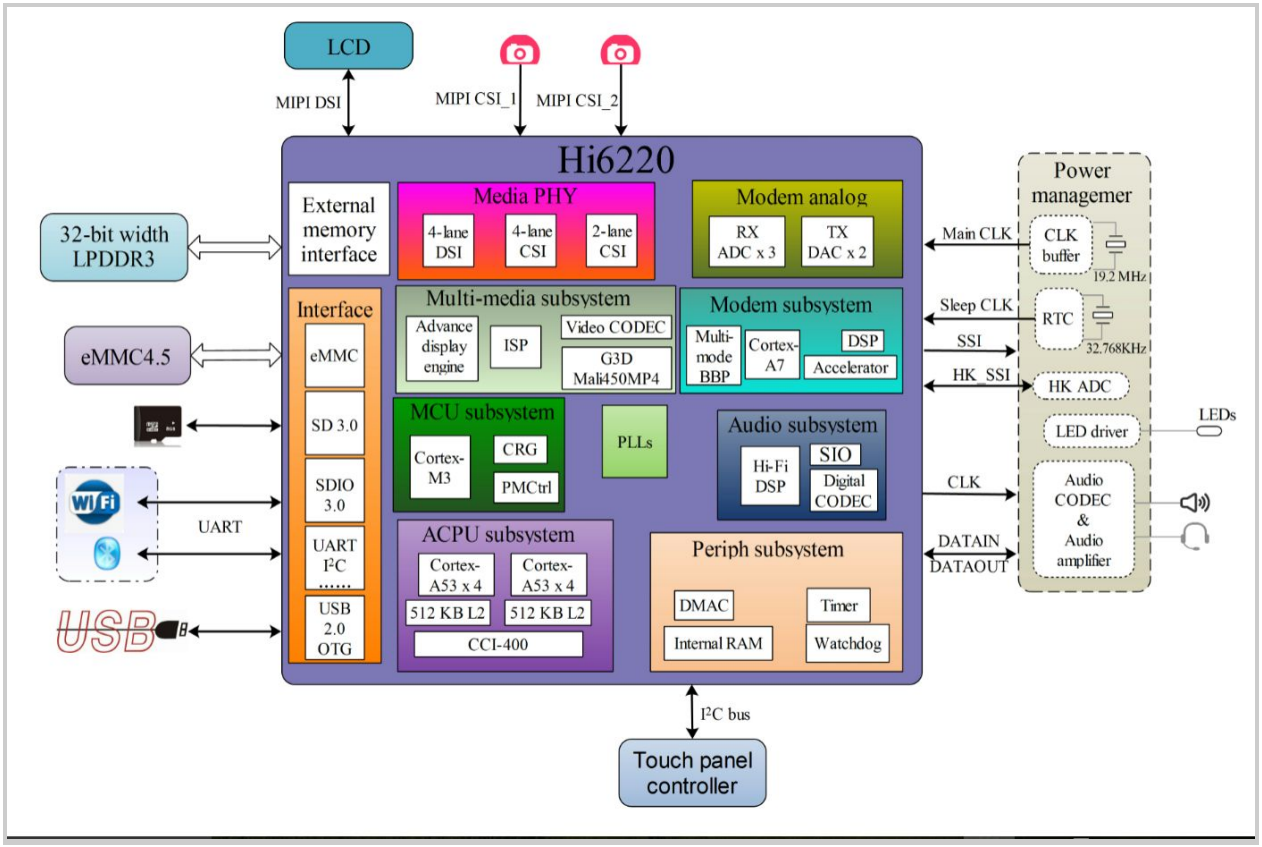
Board Overview

Key Components





System Block Diagram



Jumpers/Switch Configuration

- Auto Power Jumper□
  - CLOSED: system will boot up automatically when the power supply is connected.□
  - OPEN (default): Pressing the power switch is required to boot up the system.
- Boot Setting Jumper□
  - CLOSED: the system will attempt to program the eMMC nand flash from USB OTG source.This should only be used if the first stage bootloader is corrupted or needs to be replaced.□
  - OPEN (default): the unit boots from the first stage bootloader installed on board eMMC device.
- User Jumper□
  - Connected to GPIO3_1 on the SoC and available to the developer.□
  - CLOSED: GPIO3_1 will be pulled low.□
  - OPEN (default): GPIO3_1 will be pulled high.

Getting Started

Prerequisites

Before you power up your HiKey board for the first time you will need the following:

- HiKey board.
- A power supply with 12V@2A (suggested).
- A HDMI or DVI LCD Monitor.
- HDMI-HDMI cable or HDMI-DVI cable to connect the board to the Monitor.
- A computer keyboard with USB interface.
- A computer mouse with USB interface.

Known limitations

- The microUSB OTG port may be used (in host or slave mode) or the Type A host ports may be used. They may **not** both be used simultaneously. If a cable is inserted

into the OTG port then the Type A ports and the expansion bus port will be automatically disabled.

- For the microUSB OTG port a single Low Speed (1.5Mbit/sec), Full Speed (12Mbit/sec) or High Speed (480Mbit/sec) device is supported.
- For the USB host ports all attached USB devices must be one of the following three options:
  Low Speed (1.5Mbit/sec) and Full Speed (12Mbit/sec) devices, or
  High Speed devices (480Mbit/sec).

If a mixture of High Speed and Low/Full speed devices are attached the devices will not operate correctly. This also applies if any hubs are attached to the ports.

First Power ON

To start the board, follow these simple steps:

- step 1.Connect the HDMI cable to the HiKey HDMI connector and to the LCD Monitor.
- step 2.Connect the keyboard to the boards USB connector and the mouse to the USB connector.
- step 3.Closed the auto power jumper, please see the “Jumpers/Switch Configuration”.
- step 4.Connect the power supply to power connector P301.

Once you plug the power supply into a power outlet the board will start the booting process, and you should see Debian/Android boot up.

Component Details

Processor

The HiSilicon Kirin 620 SoC is an Integrated octa-core 64-bit ARM Cortex-A53 application processor, supports 533MHz LPDDR2, 667MHz LPDDR3, and 800MHz LPDDR3 interface, MIPI camera serial interface, embedded Mali450-MP4 GPU,1080p video encode/decode, GPS, WIFI, Bluetooth 4.1, OpenGL ES 1.1/2.0,OpenVG 1.1, ARM TrustZone security mechanism.

PMIC

HI6553V100 is a power management chip, with integrated 4-channel BUCK, 24 LDO, 1 LVS (Low Voltage Switch), a 12-channel HKADC, and 5-channel LED current driver ports. It supports under-voltage, over-voltage, over-heat, over-current protection.
BUCK1 supports 3.5A output capacity, BUCK2 has 3A output capacity, while BUCK3 and BUCK4 have 1A output capability.

In addition, there're built-in 32K Crystal and 19.2M Crystal oscillation circuits. Correspondingly there're also 3-channel 32K digital clock output, 5-channel 19.2M analog clock output, and 1-channel 19.2M digital clock output.

Memory (DRAM)

The HiKey (LeMaker version) uses a LPDDR3 DRAM chip as the memory. It provides 1GB or 2GB DRAM memory to satisfy the different requirements. a single embedded Multi Chip Package (eMCP) dual function LPDDR3/eMMC memory solution.
The LPDDR3 is a 32bit width bus implementation interfacing directly to the Kirin 620 build-in LPDDR controller. The maximum DDR clock is 800Mhz.
We can distinguish the memory capacity by the footprint on the memory chip:

K4E**8**E304EE-EGCE	**1**GB
K4E**6**E304EE-EGCE	**2**GB

Storage

eMMC

The Hikey (LeMaker version) has an on-board 8GB eMMC nand flash. The eMMC is an 8bit implementation interfacing with Kirin 620 eMMC interface supporting eMMC 4.5 specifications. and supports 1-bit, 4-bit, and 8-bit modes.

Micro SDHC

The microSDHC socket is on the bottom left corner of the PCB and is routed directly to the Kirin 620 SD 3.0 interface, and supports 1-bit and 4-bit modes (3 V and 1.8 V supported for the I/O device). The slot is a push-push type with a dedicated support for card detect signal.

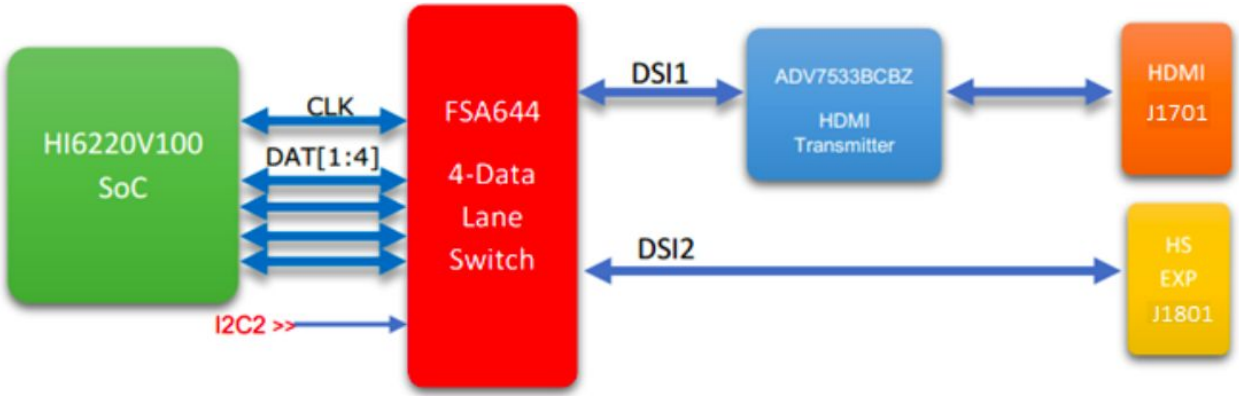
Networking

WiFi/Bluetooth LE

The HiKey board uses a TI WL1835MOD WLAN Baseband Processor and RF Transceiver which supports IEEE 802.11b, 802.11g and 802.11n WiFi and Bluetooth 4.0 (including low energy).
More features about the TI WL1835MOD can refer to:
http://processors.wiki.ti.com/index.php/WL18xx_Overview

Display Interface

As a display channel of the HI6220V100 chip, the ADE overlays graphics layers,and controls display timings. The ADE supports the RGB parallel interface that can connect to display interface IPs such as the MIPI DSI and HDMI.
Below is a block diagram of the HiKey implementation.



HDMI

The Kirin 620 doesn't include a built-in HDMI interface. The Kirin 620 deploys the built-in MIPI-DSI 4 lanes interface as the source for the HDMI output. A peripheral DSI to HDMI Bridge (Analog Devices ADV7533) performs this task and it supports a resolution from 480i to 1080p at 30Hz.□While the ADV7533 supports automatic input video form at timing detection (CEA-861E), an I2C channel from the Kirin 620 allows the user to configure the operation of this bridge. This bridge supports audio as well (meeting the 96Boards requirements to provide audio via HDMI). □Please note that the 96Boards specification calls for a MIPI-DSI interface to be routed to the High Speed Expansion connector. Since the Kirin 620 has only one MIPI-DSI interface. A mux device (FSA644UCX) is being used on the board. Only one interface, HDMI, or the Expansion MIPI-DSI can be active at a given time. The controlling signal is named' DSI_SEL_GPIO0_1'. When this signal is logic low, '0', the MIPI-DSI is routed to the DSI-HDMI Bridge. When' DSI_SEL_GPIO0_1' is logic level high, '1', the MIPI-DSI is routed to the High Speed Expansion connector.

MIPI-DSI

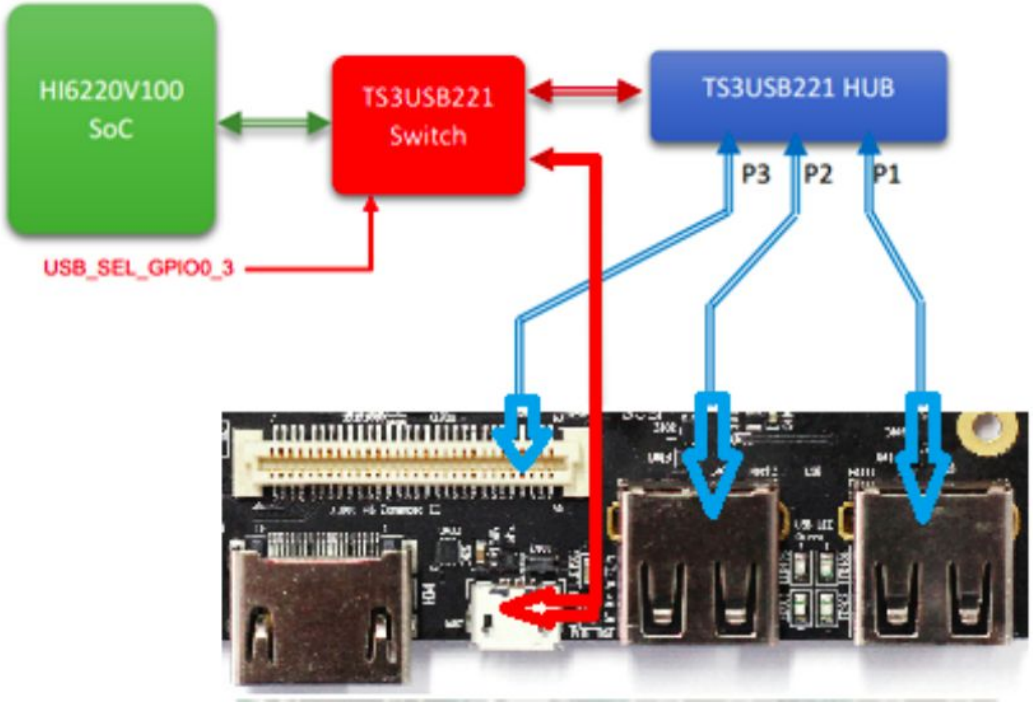
Expansion connector.The Kirin 620 implemented a four-lane MIPI_DSI interface meeting this requirement. More information about this implementation can be found in High Speed Expansion Connector.

Camera Interface

The HiKey board implements two camera interfaces, one with a four-lane MIPI_CSI interface and one with a two-lane MIPI_CSI interface, meeting this requirement. More information about this implementation can be found in [High Speed Expansion Connector].

USB Ports

There are a total of 4 USB ports on the HiKey board. Two Type-A host ports at J401 and J403, one microUSB AB 2.0 host/slave port at J402 and one USB host port available on the High Speed Expansion bus. The following block diagram shows the HiKey board implementation:



The HiKey board utilizes a single SoC USB interface without USB protocol hardware split □transfer support. The USB interfaces are therefore subject to the following restrictions:

- Either the microUSB or the Type A and LS expansion USB interfaces may be used at a time, depending on the state of USB_SEL_GPIO0_3. Both interfaces may not be used at the same time.□
- The microUSB port supports a single attached device with USB slave operations or USB host high speed, full speed or low speed operations.□
- The Type A and LS expansion USB interface cannot support mixed speed devices. All attached devices must be of the same type – high speed, full speed or low speed.□Furthermore, the HiKey board must be configured in software to support either full speed/low speed devices (default) or high speed devices on these ports.

Audio

The HiKey board uses HDMI audio as the audio output. It also has a PCM channel on the Low Speed Expansion connector.

DC Power

The 96Boards specification calls for power to be provided to the board in one of the following ways:

- An 8V to 18V power from a dedicated DC jack .
- An 8V to 18V power from the SYS_DCIN pins on the Low Speed Expansion Connector.
- Powering via USB is forbidden.

An 8V up to 18V power supply at a minimum of 2A rating can be used to provide sufficient board power for on system requirements as well as external devices. Additional current rating may be required for mezzanine boards or modules. DC Power can also be supplied via the SYS_DCIN pins on the low speed expansion.
Please see the detail information in the DC Power Input section for detailed information on Kirin 620 implementation of DC Power.

Power Measurement

The 96Boards specification calls for support for measuring power consumptions of the board. Please see the detail information in the Power Management section for the HiKey Power Measurement implementation.

External Fan Connection

The HiKey board can drive 5V or 12V cooling fans. The power for these is available on the low speed Expansion connector and can be supplied through a 2-pin 2mm male header inserted at pins SYS_5V or SYSDC_IN.

UART

The HiKey board also has an option for a Debug UART Header. This is normally used by the first stage bootloader developers, and is connected to the UART0 port of the SoC. This is available if a 2x2 male header is installed at J801. See below for the pin out of this header.

1.8V	1	2	UART0_RX
DGND	3	4	UART0_TX

And HiKey also has other UART(UART2 and UART3) on the Low Speed Expansion connector.

Please note: at now all the Linaro reference build Linux distribution will use the UART3 on the HiKey board as the debug UART.

Buttons

The 96Boards specification calls for the present of two buttons, a Power on/sleep button and a Reset button.
The HiKey meets these requirements. The power button S601 can be used to power up, power down, and reset the system. The circuit is designed such that the user will be able to manually power up, down and reset the board.

- A press and hold will power off the board if the Auto Power Jumper is not installed.
- A press and release will then power off the board.
- A press and hold for >4 seconds will reset the board.

It is also possible to connect external switches for power on/off and for hard reset.

LED Indicators

The 96Boards specifications calls for six LEDs to be implemented on the board. The specification defines the LEDs color and mechanical location on the board. There are two status LEDs and four User LEDs on the HiKey board. The user LEDs can be programmed by the SoC directly.

Two activity LEDs:

- The WiFi activity LED is a Yellow type surface mount 0603 LED. The WIFI LED on the HiKey is located beside the BT LED, this LED reflects the status of the Wi-Fi device.
- The BT activity LED is a Blue Type surface mount 0603 LED. The BT LED on the HiKey board is located next to the USB OTG connector; this LED reflects the status of the Bluetooth device.

Four User-LED's:

- The four user LEDs are surface mount Green Type 0603 LED.

Additional Functionality

JTAG

The HiKey board includes the option for soldering a 10 pin header that brings out the SoC signals for JTAG debug. A FTSH-105-01-F-DV header can be populated at J803.

Expansion Connectors

The HiKey board features two expansion connectors: one low speed expansion connector and one high speed.

Low Speed Expansion Connector

The low speed expansion connector carries GPIO and other low speed interfaces. The connector is a low profile 40 pin female 2mm receptacle (20x2) of a specified height of 4.5mm height.
The low speed expansion brings out 1.8V level SoC signals such as UART2 and UART3, I2C0 and I2C1, GPIO signals as well as SPI, PCM, Reset, 1.8V and Ground.
The following tables show the Low Speed Expansion Connector pin out:

DGND	1	2	DGND
UART2_CTS_N	3	4	PMU_PWRON_N
UART2_TX	5	6	EXP_RSTOUT_N
UART2_RX	7	8	SPI0_SCLK
UART2_RTS_N	9	10	SPI0_DI
UART3_TX	11	12	SPI0_CS_N
UART3_RX	13	14	SPIO_DO
I2C0_SCL	15	16	MODEM_PCM_XFS
I2C0_SDA	17	18	MODEM_PCM_XCLK

I2C1_SCL	19	20	MODEM_PCM_DO
I2C1_SDA	21	22	MODEM_PCM_DI
GPIO2_0	23	24	GPIO2_1
GPIO2_2	25	26	GPIO3_3
GPIO2_4	27	28	BL_PWM_GPIO12_7
GPIO6_7_DSI_TE0	29	30	GPIO2_7
ISP_RSTB0_GPIO10_3	31	32	ISP_PWDN0_GPIO9_1
ISP_RSTB1_GPIO10_3	33	34	ISP_PWDN0_GPIO9_2
LDO21_1V8	35	36	SYSDC_IN
SYS_5V	37	38	SYSDC_IN
DGND	39	40	DGND

UART {2/3}

The HiKey board implements UART2 as a 4-wire UART that connects directly to the Kirin 620. These signals are driven at 1.8V.
The HiKey board implements UART3 as a 2-wire UART that connects directly to the Kirin 620. These signals are driven at 1.8V.

I2C {0/1}

The HiKey board implements both interfaces, I2C0 and I2C1 that connects directly to the Kirin 620.

GPIO {0-19}

The Kirin 620 has 20 groups of general-purpose input/output (GPIO) pins, including GPIO0–GPIO2 in the power-on area of the system-on-chip (SoC) system and GPIO3–GPIO19 in the power-off area of the SoC system. Each GPIO group has eight programmable GPIO pins, and there are 160 GPIO pins in total. The GPIO pins are used to generate output signals or collect input signals for specific applications. The GPIO3–GPIO19 pins are multiplexed with other functional pins.

SPI 0

The HiKey board implements a full SPI master with 4 wires, CLK, CS, MOSI and MISO all connect directly to the Kirin 620.

PCM

The HiKey board implements a PCM with 3 wires, CLK, FS and DO, the optional DI signal is not implemented on the HiKey board. The I2S signals are connected directly to the Kirin 620.

Power and Reset

The HiKey board routes the PMU_PWRON_N signal to the PWRON_N pin of the HI6553V100 PMIC. This signal is driven by S601 as well, the on-board power on push-button switch.
The HiKey board routes the EXP_RSTOUT_N signal to the RSTOUT_N pin of the HI6553V100 PMIC.

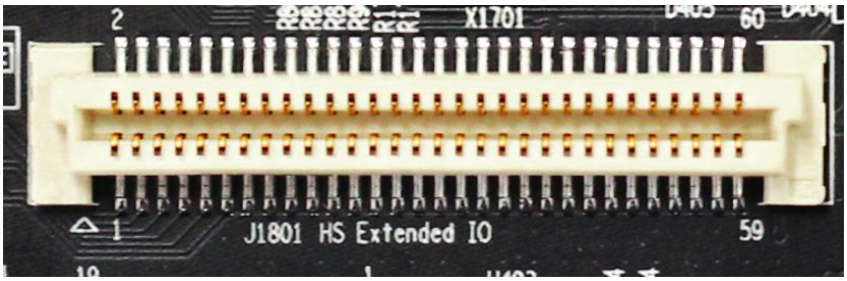
Power Supplies

The 96Boards specification calls for three power rails to be present on the Low Speed Expansion Connector:

- +1.8V : Max of 100mA.
- +5V : Able to provide a minimum of 5W of power (1A).
- SYS_DCIN :8-18V input with enough current to support all the board functions or the output DCIN from on board DC Connector able to provide a minimum of 7W of power.

High Speed Expansion Connector

The HS Expansion connector is a board to board low profile 60 pin receptacle TE part number 5177983-2.Pin1 for this header is at the bottom left corner as shown.



The following table shows the High Speed Expansion Connector pin out:

SD1_DATA0	1	2	CSI0_CLK_P
SD1_DATA1	3	4	CSI0_CLK_N
SD1_DATA2	5	6	DGND
SD1_DATA3	7	8	CSI0_DATA0_P
SD1_CLK	9	10	CSI0_DATA0_N

SD1_CMD	11	12	DGND
DGND	13	14	CSI0_DATA1_P
ISP_CCLK0	15	16	CSI0_DATA1_N
ISP_CCLK1	17	18	DGND
DGND	19	20	CSI0_DATA2_P
DSI2_CLK_P	21	22	CSI0_DATA2_N
DSI2_CLK_N	23	24	DGND
DGND	25	26	CSI0_DATA3_P
DSI2_DATA0_P	27	28	CSI0_DATA3_N
DSI2_DATA0_N	29	30	DGND
DGND	31	32	ISP0_SCL
DSI2_DATA1_P	33	34	ISP0_SDA
DSI2_DATA1_N	35	36	ISP1_SCL
DGND	37	38	ISP1_SDA
DSI2_DATA2_P	39	40	DGND
DSI2_DATA2_N	41	42	CSI1_DATA0_P
DGND	43	44	CSI1_DATA0_N
DSI2_DATA3_P	45	46	DGND
DSI2_DATA3_N	47	48	CSI1_DATA1_P
DGND	49	50	CSI1_DATA1_N
USBDP3	51	52	DGND
USBDM3	53	54	CSI1_CLK_P
DGND	55	56	CSI1_CLK_N
NOT USED	57	58	DGND
NOT USED	59	60	100K PU TO LDO5_1V8

MIPI DSI 2

The 96Boards specification calls for a MIPI-DSI to be present on the High Speed Expansion Connector. A minimum of one lane is required and up to four lanes can be accommodated on the connector.

The HiKey board implementation supports a full four lane MIPI-DSI interface that is routed to the High Speed Expansion Connector. Since the Kirin 620 has only single MIPI-DSI interface and it may be used to drive the DSI-HDMI Bridge, DSI Muxing is required.
A mux device, U1702 (FSA644UCK) is used on the board. Only one interface, HDMI, or the Expansion MIPI-DSI can be active at a given time. The controlling signal is named ' DSI_SEL_GPIO0_1'. When this signal is logic low, '0', the MIPI-DSI is routed to the DSI-HDMI Bridge.
When ' DSI_SEL_GPIO0_1' is logic level high, '1', the MIPI-DSI is routed to the High Speed Expansion connector.

MIPI CSI {0/1}

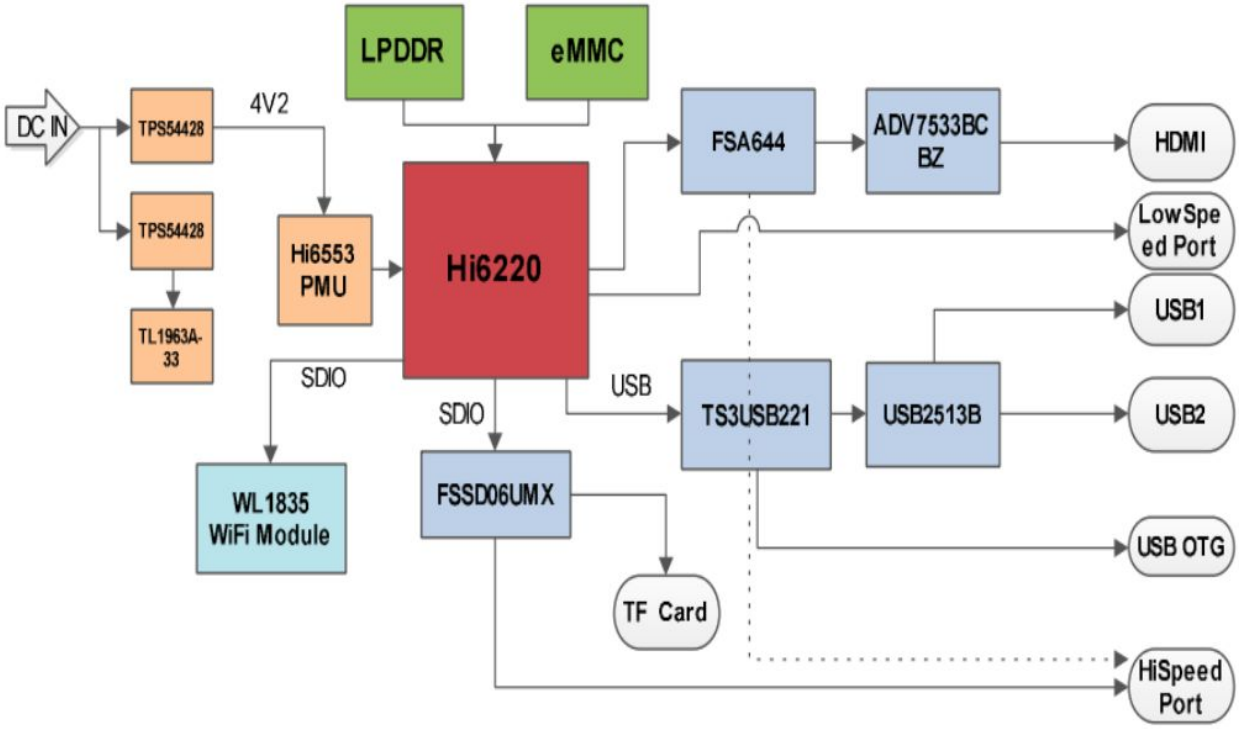
The 96Boards specification calls for two MIPI-CSI interfaces to be present on the High Speed Expansion Connector. Both interfaces are optional. CSI0 interface can be up to four lanes while CSI1 is up to two lanes.
The current HiKey board implementation supports a full four-lane MIPI-CSI interface on CSI0 and a two-lane of MIPI-CSI on CSI1. All MIPI-CSI signals are routed directly to/from the Kirin 620.

USB

The 96Boards specification calls for a USB data line interface to be present on the High Speed Expansion Connector. The HiKey board implements this requirements by routing USB channel 3 from the USB HUB to the High Speed Expansion Connector.

Power Management Overview

Block Diagram



The 96Boards specification defines how power arrives to the board and few supplies that the board needs to provide. The on board power requirement for each 96Boards implementation depends on the SoC and the set of peripherals that are specific to that implementation.
The HiKey board uses two buck regulators, U302 and U301. U302 takes the power into the board and generates 5V at 4A. This voltage feeds the USB HOST power limit switches and provides power to the Low Speed Expansion port. U301 takes the power into the board and generates 4.2V at 4A. This voltage serves as the power in voltage to the on-board PMIC, HI6553V100. The HI6553V100 can generate 22 different voltage rails.

DC Power Input

The HiKey board can be powered from one of the following ways： power to be provided in one of the following ways:

1. 8V to 18V supply from a dedicated DC jack.
   The HiKey board supports this requirement through the use of P301, 'SYS_DCIN' power connector.

Please note: the SYS_DCIN can be as low as 6.5V on the HiKey board. The power supply which is used to power the board from the DC jack should be positive outside and negative inside.

2. 8V to 18V supply from the SYS_DCIN pins on the Low Speed Expansion Connector. The HiKey board supports incoming power through this connector.
   Please note: the SYS_DCIN can be as low as 6.5V on the HiKey board.

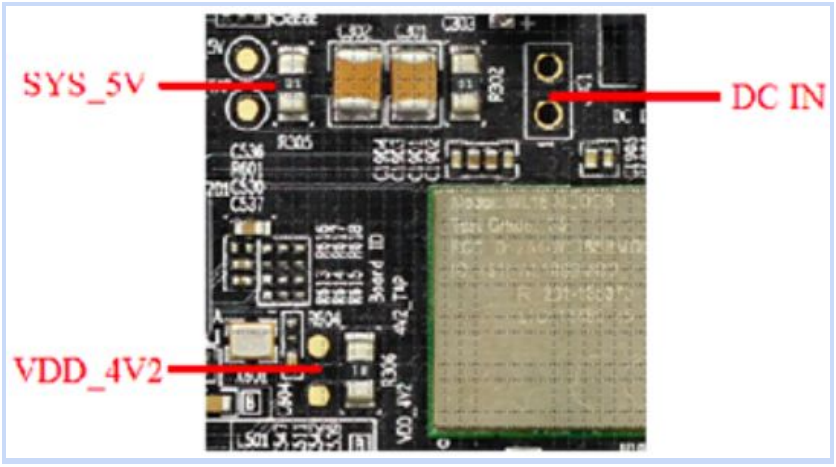
Power Source Selection and Sequencing

The HiKey board has only two sources for board incoming power. The 96Boards specification calls for only one power source to be applied to the board at any given time. Following this requirement, the user of the HiKey board should never apply power to the board from P301 and the SYS_DCIN on the Low Speed Expansion connector at the same time. There is no active or passive mechanism on the HiKey board to prioritize one source over the other.

Power Measurements

The HiKey board supports power measurement for instrumentation and testing. 0.001ohm 1206 sense resistors can be used. Installed at specific locations in place of the 0Ω resistors currently populated on the board. To connect to these sense resistors, the PCB provides footprints for 100mm 2-pin headers that can be installed. For voltage measurements, digital
GND is provided on the low speed expansion connector.The HiKey board was designed to provide current measurements for the following rails:

RESISTOR	HEADER	RAIL	MEASUREMENT
R302	J301	DC_IN	Total Base Board Power
R306		VDD_4V2	PMIC
R305		SYS_5V	HDMI, USB



Mechanical specification