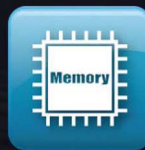


VEEK-MT-C5SOC

VEEK with Multi-touch Capacitive Panel

User Manual



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Chapter 1

Introduction of the VEEK-MT-C5SOC

The Video and Embedded Evaluation Kit - Multi-touch on Cyclone® V SOC Development Board (VEEK-MT-C5SOC) is a comprehensive design environment with everything embedded developers need to create processing-based systems. VEEK-MT-C5SOC delivers an integrated platform that includes hardware, design tools, intellectual property (IP) and reference designs for developing embedded software and hardware platform in a wide range of applications. The fully integrated kit allows developers to rapidly customize their processor and IP to best suit their specific application. The VEEK-MT-C5SOC features the Altera Cyclone® V SoC development board targeting the Altera Cyclone® V SX SoC FPGA, as well as a capacitive LCD multimedia color touch panel which natively supports multi-touch gestures. A 5-megapixel digital image sensor, ambient light sensor, and 3-axis accelerometer make up the rich feature-set.

The all-in-one embedded solution offered on the VEEK-MT-C5SOC, in combination of the LCD touch panel and digital image module, provides embedded developers the ideal platform for multimedia applications with unparallel processing performance. Developers can benefit from the use of FPGA-based embedded processing system such as mitigating design risk and obsolescence, design reuse, reducing bill of material (BOM) costs by integrating powerful graphics engines within the FPGA, and lower cost.

Figure 1-1 shows a photograph of VEEK-MT-C5SOC.



Figure 1-1 The VEEK-MT-C5SOC board overview

The key features of the board are listed below:

1.1 Cyclone V SX SoC Development Board

- Cyclone V SX SoC—5CSXFC6D6F31C6N
 - 110K LEs, 41509 ALMs
 - 5140 M10K memory blocks
 - 224 18x18 Multiplier
 - 6 FPGA PLLs and 3 HPS PLLs.
- Configuration Sources
 - Active Serial (AS) x1 or x4 configuration (EPCQ256SI16N)
 - MAX® V CPLD (5M2210ZF256I5N) in a 256-pin FBGA package as the System Controller
 - Flash fast passive parallel (FPP) configuration
 - MAX II CPLD (EPM570GM100) as part of the embedded USB-Blaster™ II for use with the Quartus® II Programmer
- Memory Devices
 - One 1,024-Mbyte (MB) HPS DDR3 SDRAM with error correction code (ECC) support
 - One 1,024-MB FPGA DDR3 SDRAM
 - One 256-Megabit (Mb) quad serial peripheral interface (QSPI) flash
 - One 512-Mb CFI flash
 - One 32-Kb I2

- C serial electrically erasable PROM (EEPROM)
 - One Micro SD flash memory card
- Switches and Indicators
 - LEDs and displays
 - Eight user LEDs
 - One configuration load LED
 - One configuration done LED
 - One error LED
 - Three configuration select LEDs
 - Four on-board USB-Blaster II status LEDs
 - One HSMC interface LED
 - Two UART data transmit and receive LEDs
 - One power on LED
 - One two-line character LCD display
 - Push buttons
 - One CPU reset push button
 - One MAX V reset push button
 - One program select push button
 - One program configuration push button
 - Six general user push buttons
 - DIP switches
 - One MAX V CPLD System Controller control switch
 - One JTAG chain control DIP switch
 - One mode select DIP switch
 - One general user DIP switch
- On-board Clocking Circuitry
 - Si570, Si571, and Si5338 programmable oscillators
 - 25-MHz, 50-MHz, 100-MHz, 125-MHz, 148.50-MHz, and 156.25-MHz
- Oscillators
 - SMA input (LVCMOS)
- Communication Ports
 - One PCI Express x4 Gen1 socket
 - One universal HSMC port
 - One USB 2.0 on-the-go (OTG) port
 - One Gigabit Ethernet port
 - Dual 10/100 Ethernet ports
 - One SDI port (option for SMA connection)
 - One controller area network (CAN) port
 - One RS-232 UART (through the mini-USB port)
 - One real-time clock

- Power
 - 14–20-V (laptop) DC input
- Mechanical
 - 5.2" × 8.2" rectangular form factor

■ Capacitive LCD Touch Screen

- Equipped with an 7-inch Amorphous-TFT-LCD (Thin Film Transistor Liquid Crystal Display) module
- Module composed of LED backlight
- Support 24-bit parallel RGB interface
- Converting the X/Y coordination of touch point to its corresponding digital data via the Touch controller.

Table 1-1 shows the general physical specifications of the touch screen (Note*).

Table 1-1 General physical specifications of the LCD

<i>Item</i>	<i>Specification</i>	<i>Unit</i>
LCD size	7-inch (Diagonal)	-
Resolution	800 x3(RGB) x 480	dot
Dot pitch	0.1926(H) x0.1790 (V)	mm
Active area	154.08 (H) x 85.92 (V)	mm
Module size	164.9(H) x 100.0(V) x 5.7(D)	mm
Surface treatment	Glare	-
Color arrangement	RGB-stripe	-
Interface	Digital	-

■ 5-Megapixel Digital Image Sensor

- Superior low-light performance
- High frame rate
- Global reset release, which starts the exposure of all rows simultaneously
- Bulb exposure mode, for arbitrary exposure times
- Snapshot-mode to take frames on **demand**
- Horizontal and vertical mirror image
- Column and row skip modes to reduce image size without reducing field-of-view
- Column and row binning modes to improve image quality when resizing
- Simple two-wire serial interface
- Programmable controls: gain, frame rate, frame size, exposure

Table 1-2 shows the key parameters of the CMOS sensor (Note*).

Table 1-2 Key performance parameters of the CMOS sensor

Parameter		Value
Active Pixels		2592Hx1944V
Pixel size		2.2umx2.2um
Color filter array		RGB Bayer pattern
Shutter type		Global reset release(GRR)
Maximum data rate/master clock		96Mp/s at 96MHz
Frame rate	Full resolution	Programmable up to 15 fps
	VGA mode	Programmable up to 70 fps
ADC resolution		12-bit
Responsivity		1.4V/lux-sec(550nm)
Pixel dynamic range		70.1dB
SNRMAX		38.1dB
Supply Voltage	Power	3.3V
	I/O	1.7V~3.1V

■ Digital Accelerometer

- Up to 13-bit resolution at +/- 16g
- SPI (3- and 4-wire) digital interface
- Flexible interrupts modes

■ Ambient Light Sensor

- Approximates human-eye response
- Precise luminance measurement under diverse lighting conditions
- Programmable interrupt function with user-defined upper and lower threshold settings
- 16-bit digital output with I2C fast-mode at 400 kHz
- Programmable analog gain and integration time
- 50/60-Hz lighting ripple rejection



Note: for more detailed information of the LCD touch panel and CMOS sensor module, please refer to their datasheets respectively.

1.2 Setup License for Terasic Multi-touch IP

To utilize the multi-touch panel in a Quartus II project, a Terasic Multi-Touch IP is required. After a license file for Quartus II is installed, there is one more license file needed to implement Terasic's Multi-touch IP. Error messages will be displayed if the license file is not added before compiling projects using Terasic Multi-touch IP. The license file is located at:

VEEK-MT-C5SOC System CD\License\license_multi_touch.dat

There are two ways to install the License. The first one is to add the license file (license_multi_touch.dat) to the licensed file listed in Quartus II, as shown in **Figure 1-2**.

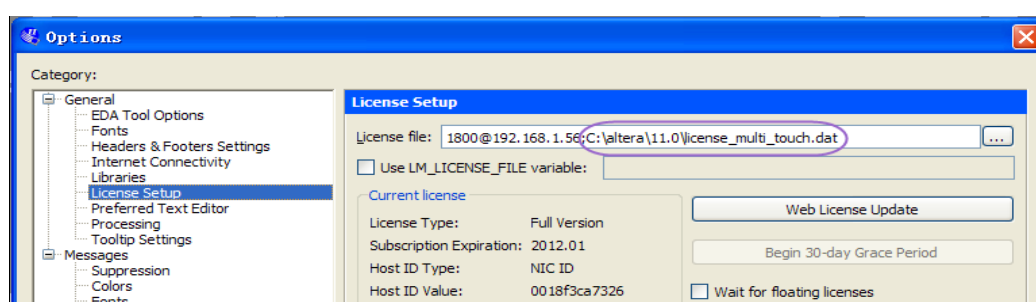


Figure 1-2 License Setup

The second way is to add license content to the existing license file. The procedures are listed below:

Use Notepad or other text editing software to open the file license_multi_touch.dat.

1. The license contains the FEATURE lines required to license the IP Cores as shown in **Figure 1-3**.

```
license_multi_touch.dat
1 FEATURE 535C_0018 alterad 9999.12 12-jan-9999 uncounted 3F15022F111E \
2  VENDOR_STRING="142c2k297gj7hoTVotLcny9Bti7hPsnSaeyATv8c8V5OsL3yQqoc1DdCIZ.
3  HOSTID=ANY TS_OK SIGN="1177 818B 8DA8 A068 5C33 BE57 9139 77D8 \
4  C855 3B4B 6582 721C 9B62 CD64 A358 0B19 40C2 15C8 B6C8 CA5B \
5  B5A9 C994 C296 D8FD E93C 9ADE 3D83 8952 EDCF 0843"
```

Figure 1-3 Content of license_multi_touch.dat

2. Open your Quartus II license.dat file in a text editor.
3. Copy everything under license_multi_touch.dat and paste it at the end of your Quartus II license file. (Note: Do not delete any FEATURE lines from the Quartus II license file. Doing so will result in an unusable license file.)
4. Save the Quartus II license file.

1.3 Getting Help

Here is the contact information should you encounter any problem:

- Terasic Technologies
- Tel: +886-3-575-0880
- Email: support@terasic.com

Chapter 2

Architecture

This chapter describes the architecture of the VEEK-MT-C5SOC including block diagram and components.

2.1 Layout and Components

The picture of the VEEK-MT-C5SOC is shown in **Figure 2-1** and **Figure 2-2**. It depicts the layout of the board and indicates the locations of the connectors and key components.



Figure 2-1 VEEK-MT-C5SOC PCB and Component Diagram (top view)



Figure 2-2 VEEK-MT-C5SOC PCB and Component Diagram (bottom view)

2.2 Block Diagram of the VEEK-MT-C5SOC

Figure 2-3 gives the block diagram of the VEEK-MT-C5SOC board. VEEK-MT-C5SOC is a Cyclone V SoC development board and a Multi-touch LCD Camera Card (MTLC) combination connected via the HSMC connector. MTLC module is not only equipped with a 7" LCD screen, it also equips a 5-Megapixel digital image sensor module, G-sensor and Light sensor. All these sensors connect to the FPGA device via the HSMC connector, so they can be controlled and directly used by the FPGA device.

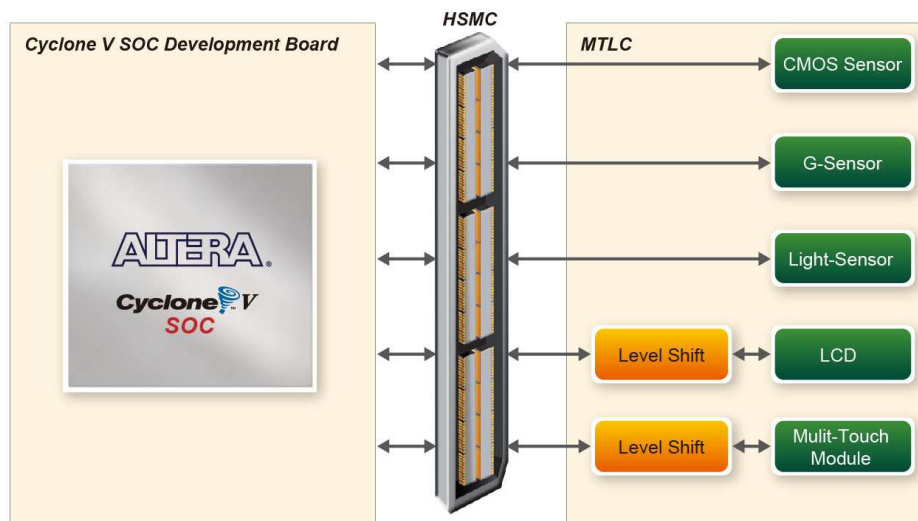


Figure 2-3 Block Diagram of VEEK-MT-C5SOC

Chapter 3

Using VEEK-MT-C5SOC

This section describes the detailed information of the components, connectors, and pin assignments of the VEEK-MT-C5SOC.

3.1 Using the Cyclone® V SX SoC FPGA

The VEEK-MT-C5SOC is composed of Cyclone V SoC development board and 7" touch panel daughter card. In this combination, the Cyclone V SoC development board which equips the FPGA device is considered as the main part. Therefore, it can refer to the User Guide (http://www.altera.com/literature/ug/ug_cv_soc_dev_kit.pdf) of Cyclone V SoC development board on the FPGA device configuration and board setup.

3.2 Using the 7" LCD Capacitive Touch Screen

The VEEK-MT-C5SOC features a 7-inch capacitive amorphous TFT-LCD panel. The LCD touch screen offers resolution of (800x480) to provide users the best display quality for developing applications. The LCD panel supports 24-bit parallel RGB data interface.

The VEEK-MT-C5SOC is also equipped with a Touch controller, which can read the coordinates of the touch points through the serial port interface of the Touch controller.

To display images on the LCD panel correctly, the RGB color data along with the data enable and clock signals must act according to the timing specification of the LCD touch panel as shown in **Table 3-1**. **Table 3-2** gives the pin assignment information of the LCD touch panel.

Table 3-1 LCD timing specifications

ITEM		SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTE
DCLK	Dot Clock	1/tCLK		33		MHZ	
	DCLK pulse duty	Tcwh	40	50	60	%	
DE	Setup time	Tesu	8			ns	
	Hold time	Tehd	8			ns	
	Horizontal period	tH		1056		tCLK	
	Horizontal Valid	tHA	800			tCLK	

	Horizontal Blank	tHB		256		tCLK	
	Vertical Period	tV		525		tH	
	Vertical Valid	tVA	480			tH	
	Vertical Blank	tVB		45		tH	
SYNC	HSYNC setup time	Thst	8			ns	
	HSYNC hold time	Thhd	8			ns	
	VSYNC Setup Time	Tvst	8			ns	
	VSYNC Hold Time	Tvhd	8			ns	
	Horizontal Period	th		1056		tCLK	
	Horizontal Pulse Width	thpw		30		tCLK	thb+thpw=46DCLK is fixed
	Horizontal Back Porch	thb		16		tCLK	
	Horizontal Front Porch	thfp		210		tCLK	
	Horizontal Valid	thd		800		tCLK	
	Vertical Period	tv		525		th	
	Vertical Pulse Width	tvpw		13		th	tvpw + tvb = 23th is fixed
	Vertical Back Porch	tvb		10		th	
	Vertical Front Porch	tvfp		22		th	
	Vertical Valid	tvd	480			th	
	Setup time	Tdsu	8			ns	
DATA	Hold time	Tdsu	8			ns	

Table 3-2 Pin assignment of the LCD touch panel

Signal Name	FPGA Pin No.	Description	I/O Standard
LCD_B0	C4	LCD blue data bus bit 0	2.5V
LCD_B1	D5	LCD blue data bus bit 1	2.5V
LCD_B2	A3	LCD blue data bus bit 2	2.5V
LCD_B3	A4	LCD blue data bus bit 3	2.5V
LCD_B4	E11	LCD blue data bus bit 4	2.5V
LCD_B5	F11	LCD blue data bus bit 5	2.5V
LCD_B6	F8	LCD blue data bus bit 6	2.5V
LCD_B7	F9	LCD blue data bus bit 7	2.5V
LCD_DCLK	E6	LCD Clock	2.5V
LCD_DE	C3	Data Enable signal	2.5V
LCD_DIM	F13	LCD backlight enable	2.5V
LCD_DITH	H8	Dithering setting	2.5V
LCD_G0	D12	LCD green data bus bit 0	2.5V
LCD_G1	E12	LCD green data bus bit 1	2.5V
LCD_G2	D10	LCD green data bus bit 2	2.5V

LCD_G3	D11	LCD green data bus bit 3	2.5V
LCD_G4	D9	LCD green data bus bit 4	2.5V
LCD_G5	E9	LCD green data bus bit 5	2.5V
LCD_G6	B5	LCD green data bus bit 6	2.5V
LCD_G7	B6	LCD green data bus bit 7	2.5V
LCD_HSD	C12	Horizontal sync input.	2.5V
LCD_MODE	G8	DE/SYNC mode select	2.5V
LCD_POWER_CTL	G10	LCD power control	2.5V
LCD_R0	A13	LCD red data bus bit 0	2.5V
LCD_R1	B13	LCD red data bus bit 1	2.5V
LCD_R2	C9	LCD red data bus bit 2	2.5V
LCD_R3	C10	LCD red data bus bit 3	2.5V
LCD_R4	B8	LCD red data bus bit 4	2.5V
LCD_R5	C8	LCD red data bus bit 5	2.5V
LCD_R6	A8	LCD red data bus bit 6	2.5V
LCD_R7	A9	LCD red data bus bit 7	2.5V
LCD_RSTB	B1	Global reset pin	2.5V
LCD_SHLR	B3	Left or Right Display Control	2.5V
LCD_UPDN	B2	Up / Down Display Control	2.5V
LCD_VSD	B11	Vertical sync input.	2.5V
TOUCH_I2C_SCL	F14	touch I2C clock	2.5V
TOUCH_I2C_SDA	F15	touch I2C data	2.5V
TOUCH_INT_n	B12	touch interrupt	2.5V

3.3 Using 5-megapixel Digital Image Sensor

The VEEK-MT-C5SOC is equipped with a 5-megapixel digital image sensor that provides an active imaging array of 2,592H x 1,944V. It features low-noise CMOS imaging technology that achieves CCD image quality. In addition, it incorporates sophisticated camera functions on-chip such as windowing, column and row skip mode, and snapshot mode.

The sensor can be operated in its default mode or programmed by the user through a simple two-wire serial interface for frame size, exposure, gain settings, and other parameters. **Table 3-3** contains the pin names and descriptions of the image sensor module.

Table 3-3 Pin assignment of the CMOS sensor

Signal Name	FPGA Pin No.	Description	I/O Standard
CAMERA_PIXCLK	AG2	Pixel clock	2.5V
CAMERA_D0	H14	Pixel data bit 0	2.5V
CAMERA_D1	G13	Pixel data bit 1	2.5V
CAMERA_D2	K12	Pixel data bit 2	2.5V
CAMERA_D3	J12	Pixel data bit 3	2.5V
CAMERA_D4	J10	Pixel data bit 4	2.5V
CAMERA_D5	J9	Pixel data bit 5	2.5V
CAMERA_D6	K7	Pixel data bit 6	2.5V
CAMERA_D7	K8	Pixel data bit 7	2.5V
CAMERA_D8	G12	Pixel data bit 8	2.5V
CAMERA_D9	G11	Pixel data bit 9	2.5V
CAMERA_D10	J7	Pixel data bit 10	2.5V
CAMERA_D11	H7	Pixel data bit 11	2.5V
CAMERA_STROBE	D6	Snapshot strobe	2.5V
CAMERA_LVAL	D7	Line valid	2.5V
CAMERA_FVAL	E8	Frame valid	2.5V
CAMERA_RESET_n	E4	Image sensor reset	2.5V
CAMERA_SCLK	AF9	Serial clock	2.5V
CAMERA_TRIGGER	C5	Snapshot trigger	2.5V
CAMERA_SDATA	AG7	Serial data	2.5V
CAMERA_XCLKIN	AJ2	External input clock	2.5V

3.4 Using the Digital Accelerometer

The VEEK-MT-C5SOC is equipped with a digital accelerometer sensor module. The ADXL345 is a small, thin, and ultralow-power-consumption 3-axis accelerometer with high resolution measurement. Digitalized output is formatted as 16-bit twos complement and could be accessed either using SPI interface or I2C interface. This chip uses the 3.3V CMOS signaling standard. Main applications include medical instrumentation, industrial instrumentation, personal electronic aid and hard disk drive protection etc. Some of the key features of this device are listed below. For more detailed information of better using this chip, please refer to its datasheet which is available on manufacturer's website or under the /datasheet folder of the system CD.

Table 3-4 contains the pin names and descriptions of the G sensor module.

<i>Signal Name</i>	<i>FPGA Pin No.</i>	<i>Description</i>	<i>I/O Standard</i>
GSENSOR_INT1	E3	Interrupt 1 output	2.5V
GSENSOR_INT2	E2	Interrupt 2 output	2.5V
GSENSOR_CS_n	D4	Chip Select	2.5V
GSENSOR_ALT_ADDR	E1	I2C Address Select	2.5V
GSENSOR_SDA_SDI_SDIO	D1	Serial Data	2.5V
GSENSOR_SCL_SCLK	D2	Serial Communications Clock	2.5V

3.5 Using the Ambient Light Sensor

The APDS-9300 is a low-voltage digital ambient light sensor that converts light intensity to digital signal output capable of direct I2C communication. Each device consists of one broadband photodiode (visible plus infrared) and one infrared photodiode. Two integrating ADCs convert the photodiode currents to a digital output that represents the irradiance measured on each channel. This digital output can be input to a microprocessor where luminance (ambient light level) in lux is derived using an empirical formula to approximate the human-eye response. For more detailed information of better using this chip, please refer to its datasheet which is available on manufacturer's website or under the /datasheet folder of the system CD.

Table 3-5 contains the pin names and descriptions of the ambient light sensor module.

<i>Signal Name</i>	<i>FPGA Pin No.</i>	<i>Description</i>	<i>I/O Standard</i>
LSensor_ADDR_SEL	A6	Chip select	2.5V
LSensor_INT	B7	Interrupt output	2.5V
LSensor_SCL	A5	Serial Communications Clock	2.5V
LSensor_SDA	C7	Serial Data	2.5V

3.6 Using Terasic Multi-touch IP

Terasic Multi-touch IP is provided for developers to retrieve user inputs, including multi-touch gestures and single-touch. The file name of this IP is **i2c_touch_config** and it is encrypted. To compile projects with the IP, users need to install the IP license first. For license installation, please refer to section **1.2 Setup License for Terasic Multi-touch IP** in this document. The license file is located at:

VEEK-MT-C5SOC System CD\License\license_multi_touch.dat

The IP decodes I2C information and outputs coordinate and gesture information. The IP interface is shown below:

```

module i2c_touch_config (
    // Host Side
    iCLK,
    iRSTN,
    iTRIG,
    oREADY,
    oREG_X1,
    oREG_Y1,
    oREG_X2,
    oREG_Y2,
    oREG_TOUCH_COUNT,
    oREG_GESTURE,
    // I2C Side
    I2C_SCLK,
    I2C_SDAT
);

```

The signal purpose of the IP is described in [Table 3-6](#). The IP requires a 50 MHz signal as a reference clock to the **iCLK** pin and system reset signal to **iRSTN**. **iTRIG**, **I2C_SCLK**, and **I2C_SDAT** pins should be connected of the TOUCH_INT_n, TOUCH_I2C_SCL, and TOUCH_I2C_SDA signals in the 2x20 GPIO header respectively. When **oREADY** rises, it means there is touch activity, and associated information is given in the **oREG_X1**, **oREG_Y1**, **oREG_X2**, **oREG_Y2**, **oREG_TOUCH_COUNT**, and **oREG_GESTURE** pins.

For the control application, when touch activity occurs, it should check whether the value of **oREG_GESTURE** matched a pre-defined gesture ID defined in [Table 3-7](#). If it is not a gesture, it means a single-touch has occurred and the relative X/Y coordinates can be derived from **oREG_X1** and **oREG_Y1**.

Table 3-6 Interface Definitions of Terasic Multi-touch IP

<i>Pin Name</i>	<i>Direction</i>	<i>Description</i>
iCLK	Input	Connect to 50MHz Clock
iRSTN	Input	Connect to system reset signal
iTRIG	Input	Connect to Interrupt Pin of Touch IC
oREADY	Output	Rising Trigger when following six output data is valid
oREG_X1	Output	10-bits X coordinate of first touch point
oREG_Y1	Output	9-bits Y coordinate of first touch point
oREG_X2	Output	10-bits X coordinate of second touch point
oREG_Y2	Output	9-bits Y coordinate of second touch point
oREG_TOUCH_COUNT	Output	2-bits touch count. Valid value is 0, 1, or 2.
oREG_GESTURE	Output	8-bits gesture ID (See Table 3-7)
I2C_SCLK	Output	Connect to I2C Clock Pin of Touch IC
I2C_SDAT	Inout	Connect to I2C Data Pin of Touch IC

The supported gestures and IDs are shown in [Table 3-7](#).

Table 3-7 Gestures

Gesture	ID (hex)
One Point Gesture	
North	0x10
North-East	0x12
East	0x14
South-East	0x16
South	0x18
South-West	0x1A
West	0x1C
North-West	0x1E
Rotate Clockwise	0x28
Rotate Anti-clockwise	0x29
Click	0x20
Double Click	0x22
Two Point Gesture	
North	0x30
North-East	0x32
East	0x34
South-East	0x36
South	0x38
South-West	0x3A
West	0x3C
North-West	0x3E
Click	0x40
Zoom In	0x48
Zoom Out	0x49

Note: The Terasic IP Multi-touch IP can also be found under the \IP folder in the system CD as well as the \IP folder in the reference designs.

Chapter 4

VEEK-MT-C5SOC Demonstrations

This chapter gives detailed description of the provided bundles of exclusive demonstrations implemented on VEEK-MT-C5SOC. These demonstrations are particularly designed (or ported) for VEEK-MT-C5SOC, with the goal of showing the potential capabilities of the kit and showcase the unique benefits of FPGA-based SOPC systems such as reducing BOM costs by integrating powerful graphics and video processing circuits within the FPGA.

4.1 System Requirements

To run and recompile the demonstrations, you should:

- Install Altera Quartus II 13.0 and NIOS II EDS 13.0 or a later edition on the host computer
- Install the USB-Blaster II driver software.
- Copy the entire demonstrations folder from the VEEK-MT-C5SOC system CD to your host computer

4.2 Painter Demonstration

This chapter shows how to control LCD and touch controller to establish a paint demo based on Qsys and Altera VIP Suite. The demonstration shows how multi-touch gestures and single-touch coordinates operate.

Figure 4-1 shows the hardware system block diagram of this demonstration. For LCD display processing, the reference design is developed based on the Altera Video and Image Processing Suite (VIP). The Frame Reader VIP is used for reading display content from the associated video memory, and VIP Video Out is used to display the display content. The display content is filled by NIOS II processor according to users' input.

For multi-touch processing, a Terasic Memory-Mapped IP is used to retrieve the user input, including multi-touch gesture and single-touch resolution. Note, the IP is encrypted, so the license should be installed before compiling the Quartus II project. For IP--usage details please refer to the section **3.6 Using Terasic Multi-touch IP** in this document.

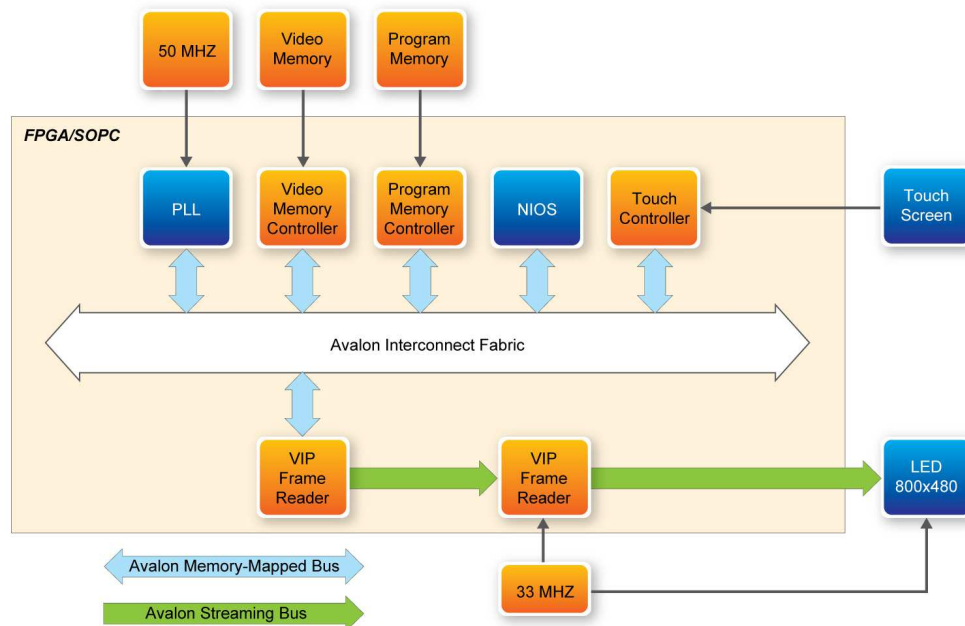


Figure 4-1 Block diagram of the Painter demonstration

■ Demonstration Source Code

- Project directory: Painter
- Bit stream used: Painter.sof
- Nios II Workspace: Painter \Software

■ Demonstration Batch File

Demo Batch File Folder: Painter \demo_batch

The demo batch file includes the following files:

- Batch File: test.bat, test_bashrc
- FPGA Configure File: Painter.sof
- Nios II Program: Painter.elf

■ Demonstration Setup

- Make sure Quartus II and Nios II are installed on your PC
- Power on the Cyclone V SoC development board
- Connect USB-Blaster to the Cyclone V SoC development board and install USB-Blaster driver if necessary

- Execute the demo batch file “test.bat” under the batch file folder, Painter \demo_batch
- After Nios II program is downloaded and executed successfully, you will see a painter GUI in the LCD. **Figure 4-2** shows the GUI of the Painter Demo.
- The GUI is classified into three areas: Palette, Canvas, and Gesture. Users can select pen color from the color palette and start painting in the Canvas area. If gesture is detected, the associated gesture symbol is shown in the gesture area. To clear canvas content, click the “Clear” button.
- **Figure 4-3** shows the photo when users paint in the canvas area. **Figure 4-4** shows the phone when counter-clockwise rotation gesture is detected. **Figure 4-5** shows the photo when zoom-in gesture is detected.



Figure 4-2 GUI of Painter Demo



Figure 4-3 Single Touch Painting



Figure 4-4 Counter-clockwise Rotation Gesture



Figure 4-5 Zoom-in Gesture



Note: execute the test.bat under Picture_Viewer\demo_batch will automatically download the .sof and .elf file.

4.3 Camera Application

This demonstration shows a digital camera reference design using the 5-Megapixel CMOS sensor and 8-inch LCD modules on the VEEK-MT-C5SOC. The CMOS sensor module sends the raw image data to FPGA on the Altera Cyclone® V SoC board, the FPGA on the board handles image processing part and converts the data to RGB format to display on the LCD module. The I2C Sensor Configuration module is used to configure the CMOS sensor module. **Figure 4-6** shows the block diagram of the demonstration.

As soon as the configuration code is downloaded into the FPGA, the I2C Sensor Configuration block will initial the CMOS sensor via I2C interface. The CMOS sensor is configured as follow:

- Row and Column Size: 800 * 480
- Exposure time: Adjustable
- Pix clock: $MCLK * 2 = 25 * 2 = 50\text{MHz}$
- Readout modes: Binning
- Mirror mode: Line mirrored

According to the settings, we can calculate the CMOS sensor output frame rate is about 44.4 **fps**.

After the configuration, The CMOS sensor starts to capture and output image data streams, the CMOS sensor Capture block extracts the valid pix data streams based on the synchronous signals from the CMOS sensor. The data streams are generated in Bayer Color Pattern format. So it's then converted to RGB data streams by the RAW2RGB block.

After that, the Multi-Port SDRAM Controller acquires and writes the RGB data streams to the SDRAM which performs as a frame buffer. The Multi-Port SDRAM Controller has two write ports and read ports also with 16-bit data width each. The writing clock is the same as CMOS sensor pix clock, and the reading clock is provided by the LCD Controller, which is 33MHz.

Finally, the LCD controller fetches the RGB data from the buffer and displays it on the LCD panel continuously. Because the resolution and timing of the LCD is compatible with WVGA@800*480, the LCD controller generates the same timing and the frame rate can achieve about 25 fps.

For the objective of a better visual effect, the CMOS sensor is configured to enable the left right mirror mode. User could disable this functionality by modifying the related register value being written to CMOS controller chip.

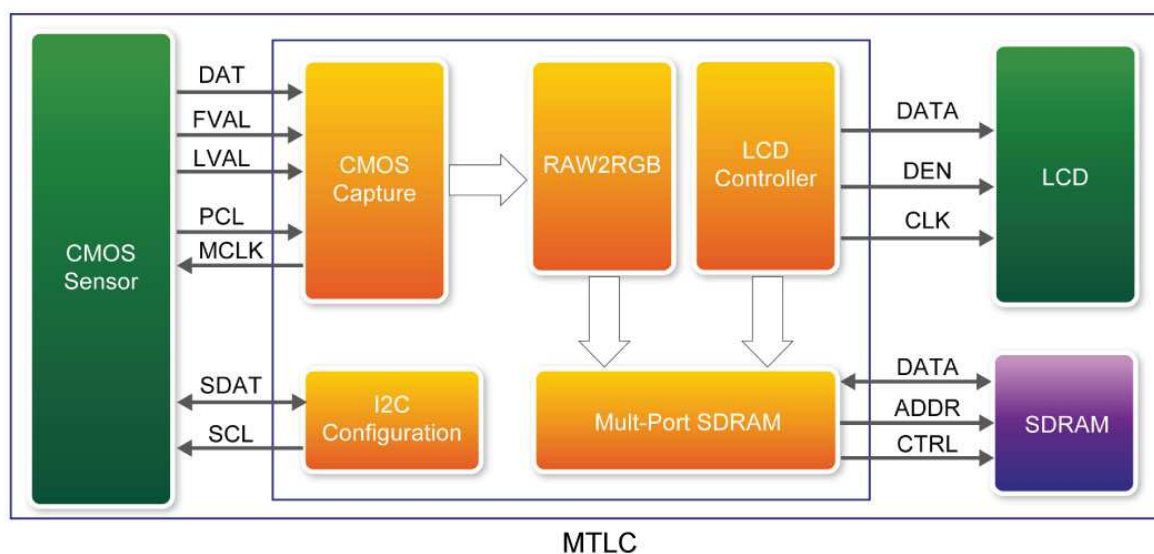


Figure 4-6 Block diagram of the digital camera design

■ Demonstration Source Code

- Project directory: Camera
- Bit stream used: Camera.sof

■ Demonstration Batch File

Demo Batch File Folder: Camera\demo_batch

The demo batch file includes the following files:

- Batch File: test.bat
- FPGA Configure File: Camera.sof

■ Demonstration Setup

- Load the bit stream into FPGA by executing the batch file 'test.bat' under Camera\demo_batch\ folder
- The system enters the FREE RUN mode automatically. Press S6 on the Altera Cyclone® V SoC board to reset the circuit
- User can use the SW1.5 and S5 to set the exposure time for brightness adjustment of the image captured. When SW1.5 is set to Off, the brightness of image will be increased as S5 is pressed longer. If SW1.5 is set to On, the brightness of image will be decreased as S5 is pressed shorter
- User can use SW1.8 to mirror image of the line. However, remember to press S6 after toggle SW1.8]



Note: execute the test.bat under Camera\demo_batch will automatically download the .sof file.

Table 4-1 and Figure 4-7 summarizes the functional keys of the digital camera. **Figure 4-8** gives a run-time photograph of the demonstration.

Table 4-1 The functional keys of the digital camera demonstration

Component	Function Description
S6	Reset circuit
S5	Set the new exposure time (use with SW1.5)
SW1.5	Off: Extend the exposure time
	On: Shorten the exposure time
S1.8	Mirror image (use with S6)





4.4 Digital Accelerometer Demonstration

This demonstration shows a bubble level implementation based on a digital accelerometer. We use I²C protocol to control the ADXL345 digital accelerometer, and the APDS-9300 Miniature Ambient Light Photo Sensor. The LCD displays the interface of our game. When tilting the VEEK-MT-C5SOC, the ADXL345 measures the static acceleration of gravity. In our Nios II software, we compute the change of angle in the x-axis and y-axis, and show angle data in the LCD display. The value of light sensor will change as the brightness changes around the light-sensor.

Figure 4-9 shows the hardware system block diagram of this demonstration. The system is clocked by an external 50MHz Oscillator. Through the internal PLL module, the generated 150MHz clock is used for Nios II processor and other components, and there is also 10MHz for low-speed peripherals.

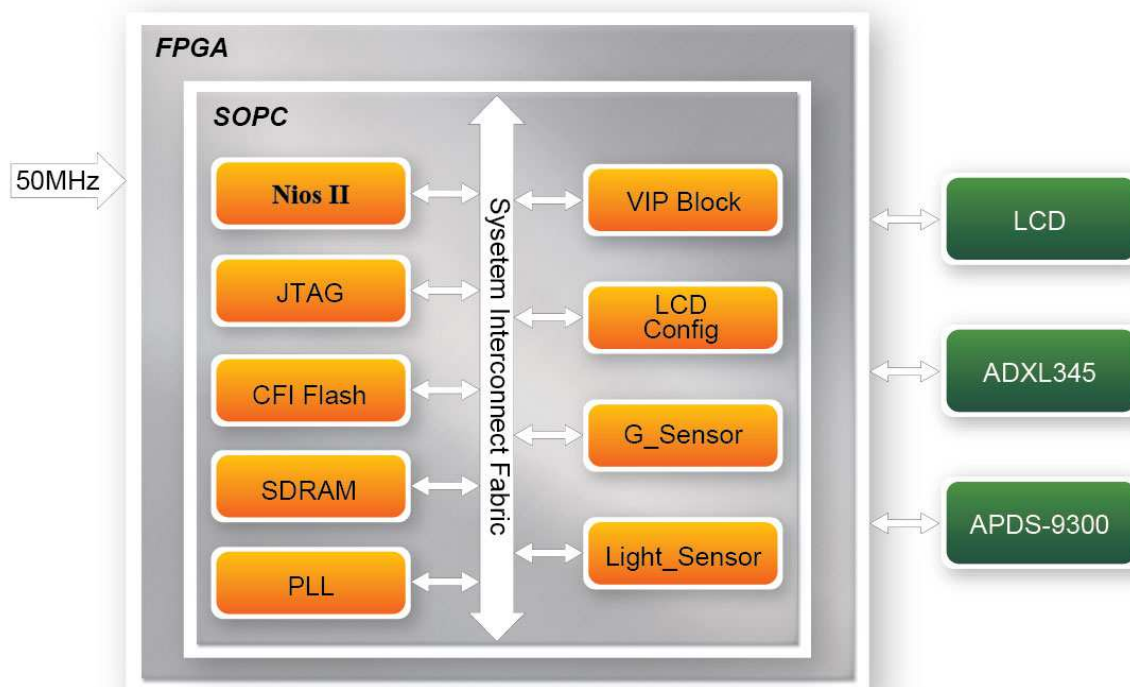


Figure 4-9 Block diagram of the digital accelerometer demonstration

■ Demonstration Source Code

- Project directory: G_sensor
- Bit stream used: G_sensor.sof
- Nios II Workspace: G_sensor\Software

■ Demonstration Batch File

Demo Batch File Folder: G_sensor\demo_batch

The demo batch includes the following files:

- Batch File: G_sensor.bat, test_bashrc
- FPGA Configure File: G_sensor.sof
- Nios II Program: G_sensor.elf

■ Demonstration Setup

- Load the bit stream into the FPGA on the VEEK-MT-C5SOC.
- Run the Nios II Software under the workspace G_sensor\Software (Note*).
- After the Nios II program is downloaded and executed successfully, a prompt message will be displayed in nios2-terminal: “its ADXL345’s ID = e5”.
- Tilt the VEEK-MT-C5SOC to all directions, and you will find that the angle of the g-sensor and value of light sensor will change. When turning the board from -80° to -10° and from 10° to 80° in Y-axis, or from 10° to 80° and from -80° to -10° in Y-axis, the image will invert **Figure 4-10** shows the demonstration in action.



Figure 4-10 Digital Accelerometer demonstration



Note:

Execute `G_sensor\demo_batch\test.bat` to download .sof and .elf files.

Chapter 5

Appendix

5.1 Revision History

<i>Version</i>	<i>Change Log</i>
V1.0	Initial Version (Preliminary)

5.2 Copyright Statement

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