



太欣半導體股份有限公司  
SYNTEK SEMICONDUCTOR CO., LTD.

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# **USB 2.0 Video Class**

## **PC Camera Controller**

**STK2139**

**Datasheet**

Released Version: V1.4



## Content

<b>1 PRODUCT OVERVIEW .....</b>	<b>4</b>
<b>2 FUNCTIONAL BLOCK DIAGRAM.....</b>	<b>5</b>
<b>3 PRODUCT FEATURES .....</b>	<b>6</b>
3.1 SENSOR INTERFACE .....	6
3.2 IMAGE PROCESSING ENGINE .....	6
3.3 INTEGRATED HI-SPEED USB 2.0 TRANSCEIVER.....	6
3.4 SERIAL BUS INTERFACES.....	7
3.5 SPI INTERFACE.....	7
3.6 MICRO CONTROLLER.....	7
3.7 USB VIDEO CLASS (UVC) .....	8
3.8 GENERAL PURPOSE INPUT/OUTPUT INTERFACE.....	8
3.9 POWER MANAGEMENT .....	8
3.10 PLATFORM SUPPORT.....	9
<b>4 APPLICATION SOLUTIONS.....</b>	<b>10</b>
<b>5 PIN DIAGRAM.....</b>	<b>11</b>
5.1 48-PIN DIAGRAM.....	11
<b>6 PIN DESCRIPTIONS.....</b>	<b>12</b>
6.1 48-PIN DESCRIPTIONS.....	12
<b>7 ELECTRICAL CHARACTERISTICS.....</b>	<b>14</b>
7.1 ABSOLUTE MAXIMUM RATINGS.....	14
7.2 DC ELECTRICAL CHARACTERISTICS .....	15
7.3 AC ELECTRICAL CHARACTERISTICS .....	16
<b>8 PACKAGE DIMENSIONS.....</b>	<b>19</b>
8.1 48-PIN LD QFN PACKAGE, 6X6X0.85MM.....	19
<b>9 CONTACT INFORMATION .....</b>	<b>21</b>
<b>10 REVISION HISTORY .....</b>	<b>22</b>



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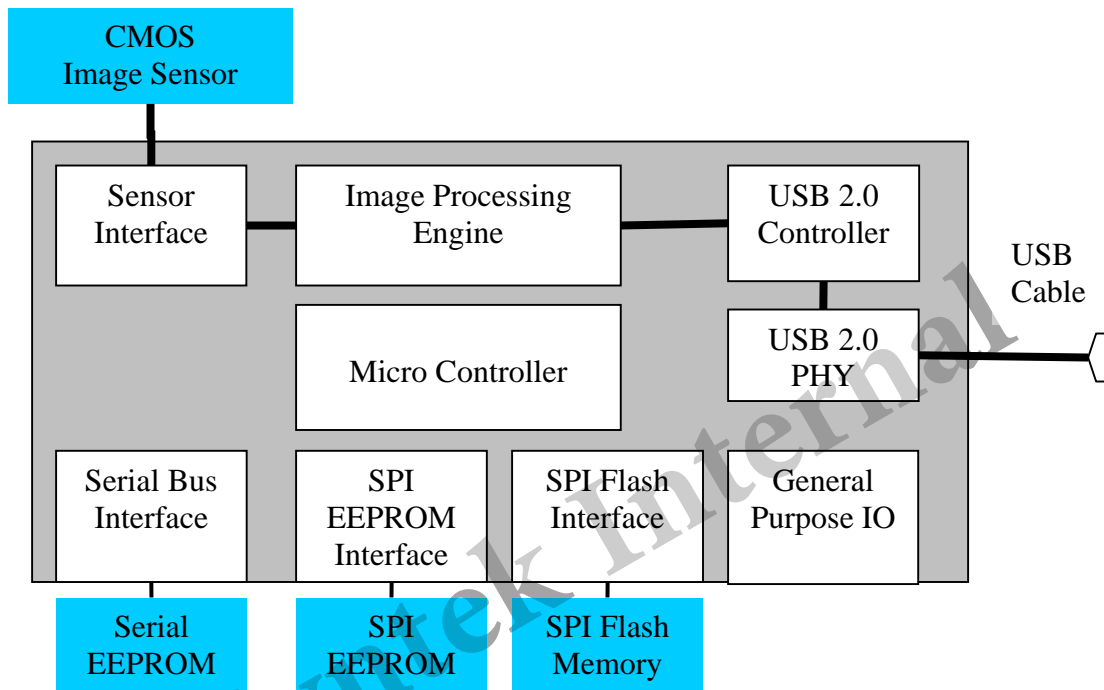
## 1 Product Overview

STK2139 is a highly integrated, USB 2.0 compliant single chip NB camera / PC camera controller. Utilizing a high-speed, high-bandwidth isochronous pipe, it is able to transfer image data at the rate up to 24MB/s. An interrupt pipe is available to carry status to USB host.

STK2139 is optimized to support image sensors with YUV data output. The processed resolutions can be up to 2MP image sensor. The image data can be further processed by adjusting brightness, contrast, hue, and saturation.

STK2139 supports serial flash or EEPROM to store data and program code for internal 8051. This adds system flexibility to support variant image sensors.

## 2 Functional Block Diagram



STK2139 Functional Block Diagram

## 3 Product Features

### 3.1 Sensor Interface

1. Support up to 2MP (1600x1200) resolution from CMOS image sensor.
2. Support 8-bit ITU-R 601 interface standard, and compliance with 10-bit sensor data inputs.
3. Support YUV image with pixel clock up to 60MHz from CMOS image sensor.
4. Support up to 48MHz output clock to CMOS image sensor.
5. Support industrial 2-wire serial interface to CMOS image sensor.
6. Support hardware windowing and decimation.

### 3.2 Image Processing Engine

1. Brightness Control
2. Contrast Control
3. Hue Control
4. Saturation Control
5. Privacy Control
6. 2D Noise Removal Medium Filter (up to 1280 pixels per line)

### 3.3 Integrated Hi-Speed USB 2.0 Transceiver

1. USB 2.0 high-speed and full-speed compliant
2. USB Video Class 1.0a and 1.1 compliant
3. High-speed isochronous video pipe can transfer up to 24 MB/sec.
4. Full-speed isochronous video pipe can transfer up to 0.99 MB/sec.



5. High-speed isochronous video pipe supports 6 alternative settings.
6. Full-speed isochronous video pipe supports 3 alternate settings.
7. High / full-speed interrupt pipe can transfer up to 8 bytes per payload
8. Support all test modes defined in the USB 2.0 specification

### 3.4 Serial Bus Interfaces

1. Support a serial communication to CMOS image sensors.
2. Support adjustable serial clock rate to CMOS image sensors.
3. Support a serial communication to external serial EEPROM.
4. Support adjustable clock rate to serial EEPROM.

### 3.5 SPI Interface

1. Support SPI mode 0 and mode 3 communication to external SPI flash.
2. Support SPI mode 0 and mode 3 communication to external SPI EEPROM.
3. Support adjustable clock rate to external SPI EEPROM.

### 3.6 Micro Controller

1. Embedded 4T 8051 CPU
2. 24MHz CPU clock rate
3. Total 40KB program memory includes 32KB mask ROM and 8KB SRAM.
4. 256B direct access data memory and 1KB indirect access data memory
5. Power-on reset loads 8KB codes from external EEPROM or flash.
6. USB Video Class descriptors can be loaded from external EEPROM or flash.



7. USB Video Class and sensor parameters can be loaded from external EEPROM or flash.
8. Content of external EEPROM or flash can be upgraded from PC utilities.

### **3.7 USB Video Class (UVC)**

1. Brightness Control
2. Contrast Control
3. Hue Control
4. Saturation Control
5. White Balance Temperature Control
6. Backlight Compensation
7. Sharpness Control by CMOS image sensor
8. Gamma Control by CMOS image sensor
9. Power Line Frequency Control by CMOS image sensor
10. Privacy Control
11. Image flipping control triggered by GPIO and CMOS image sensor
12. LED indicator on video streaming
13. Still Image Capture up to 2.0MP and still image capture method 1 and 2

### **3.8 General Purpose Input/Output Interface**

10 general purpose input/output pins

### **3.9 Power Management**

1. 1.8V power supply voltage for chip core.
2. 1.8V and 3.3V power supply voltage for on-chip USB transceiver.
3. 3.3V power supply voltage for IO.





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4. Embedded LDO provides a wide voltage range from 1.6V to 3.1V for sensor power.
  5. Support advance power down mechanism.

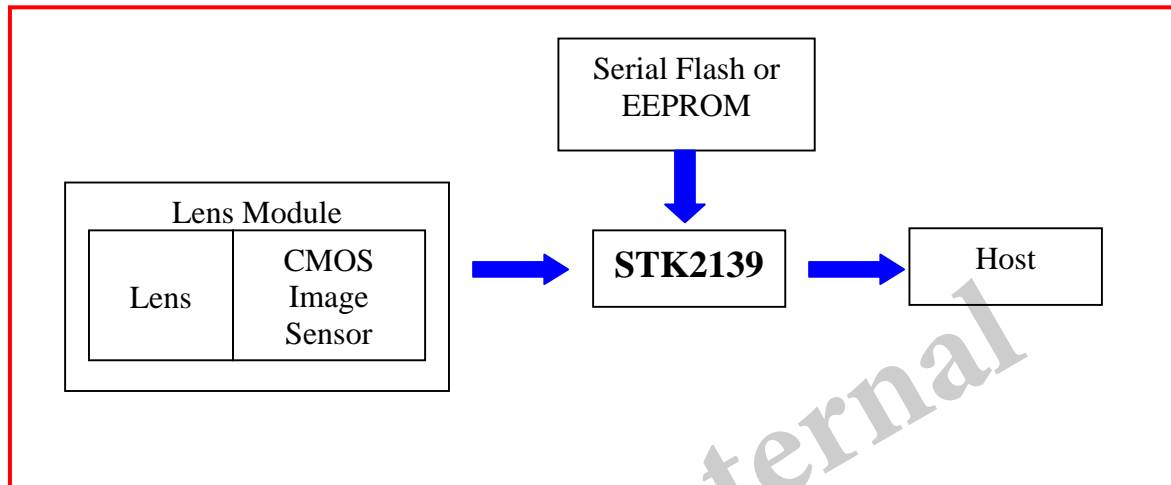
### 3.10 Platform Support

1. Microsoft Windows XP SP2 and later release
2. Microsoft Windows CE 6.0 and later release
3. Mac: OS X 10.4.9 or later
4. Linux: Linux Kernel 2.6.26 and later release

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## 4 Application Solutions

### High speed USB 2.0 PC Camera Solution



1. CMOS image sensor provides YUV image data to STK2139.
2. STK2139 transfers processed YUV image data to host.
3. Serial Flash or EEPROM provides the customized 8051 program codes and data.
4. Power for the overall solution is from USB cable from host, no additional power supply is necessary.



## 5 Pin Diagram

### 5.1 48-pin diagram

		VSS	VDD_IO	SDATA3	SDATA2	SDATA1	SDATA0	VSYNC	HSYNC	CLKS	CLKOUT	VDD_CORE	NC (RX)	
		48	47	46	45	44	43	42	41	40	39	38	37	
SDATA4	1													36 NC (TX)
SDATA5	2													35 VSS
SDATA6	3													34 REXT
SDATA7	4													33 VD33_PHY
GPIO0	5													32 DP
GPIO1	6													31 DM
GPIO2	7													30 VSS_PHY
GPIO3	8													29 XI_12
SPICLK	9													28 XO_12
SPICS	10													27 VD18_PHY
SPIDI	11													26 VDD_IO
SPIDO	12													25 VSS
		13	14	15	16	17	18	19	20	21	22	23	24	
		GPIO4	GPIO5	GPIO6	GPIO7	GPIO8	GPIO9	I2CDATA	I2CCLK	POWERONRESET	LDO_VO1	VDD_LDO	LDO_VO2	

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## 6 Pin Descriptions

### 6.1 48-pin Descriptions

Pin#	Name	Dir	Pull	Notes	Description
1	SDATA4	I	PD		Sensor data input bit 4
2	SDATA5	I	PD		Sensor data input bit 5
3	SDATA6	I	PD		Sensor data input bit 6
4	SDATA7	I	PD		Sensor data input bit 7
5	GPIO0	I/O	PD		General purpose I/O 0
6	GPIO1	I/O	PD		General purpose I/O 1
7	GPIO2	I/O	PD		General purpose I/O 2
8	GPIO3	I/O	PD		General purpose I/O 3
9	SPICLK	O	PD		SPI EEPROM/flash clock
10	SPICS	O			SPI EEPROM/flash select
11	SPIDI	I	PD		SPI EEPROM/flash data input
12	SPIDO	O			SPI EEPROM/flash data output
13	GPIO4	I/O	PD	24mA	General purpose I/O 4
14	GPIO5	I/O	PD	24mA	General purpose I/O 5
15	GPIO6	I/O	PU		General purpose I/O 6
16	GPIO7	I/O	PD		General purpose I/O 7
17	GPIO8	I/O	PD		General purpose I/O 8
18	GPIO9	I/O	PD		General purpose I/O 9
19	I2CDATA	I/O			Serial bus data
20	I2CCLK	O			Serial bus clock
21	POWERONRESET	I			Low Active Power On Reset
22	LDO_VO1	O			LDO output (1.6V~3.1V, typical 1.8V) (Provide 1.8V supply for core internally)
23	VDD_LDO	I			Supply for LDO (2.8V~5.5V, typical 3.3V)
24	LDO_VO2	O			LDO output (1.6V~3.1V, typical 2.5V)

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Pin#	Name	Dir	Pull	Notes	Description
25	VSS	I			Ground
26	VDD_IO	I			3.3V supply for IO
27	VD18_PHY	I			1.8V supply for transceiver
28	XO_12	O			12 MHz oscillator output for USB
29	XI_12	I			12 MHz oscillator input for USB
30	VSS_PHY	I			Ground for transceiver
31	DM	I/O			USB D minus line
32	DP	I/O			USB D plus line
33	VD33_PHY	I			3.3V supply for transceiver
34	REXT	I			Connect 330 ohm resistor to ground.
35	VSS	I			Ground
36	NC	I	PU		(UART TX)
37	NC	O	PU		(UART RX)
38	VDD_CORE	I			1.8V supply for core
39	CLKOUT	O	PD		Sensor clock output
40	CLKS	I	PD		Sensor clock input
41	HSYNC	I/O	PD		Horizontal sync signal
42	VSYNC	I/O	PD		Vertical sync signal
43	SDATA0	I	PD		Sensor data input bit 0
44	SDATA1	I	PD		Sensor data input bit 1
45	SDATA2	I	PD		Sensor data input bit 2
46	SDATA3	I	PD		Sensor data input bit 3
47	VDD_IO	I			3.3V supply for IO
48	VSS	I			Ground

Note: GPIO4 and GPIO5 use IO pad with 24mA function, while others use IO pad with 8mA function.

## 7 Electrical Characteristics

### 7.1 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Power supply voltage for I/O	$V_{DD33}$	-0.5 to +4.6	V
Power supply voltage for core	$V_{DD}$	-0.5 to +2.5	V
Input voltage	$V_I$	-0.5 to +6	V
Output voltage	$V_O$	-0.5 to +4.6	V
Operating temperature range	$T_{OPT}$	-40 to +125	°C
Storage temperature range	$T_{STG}$	-65 to +150	°C

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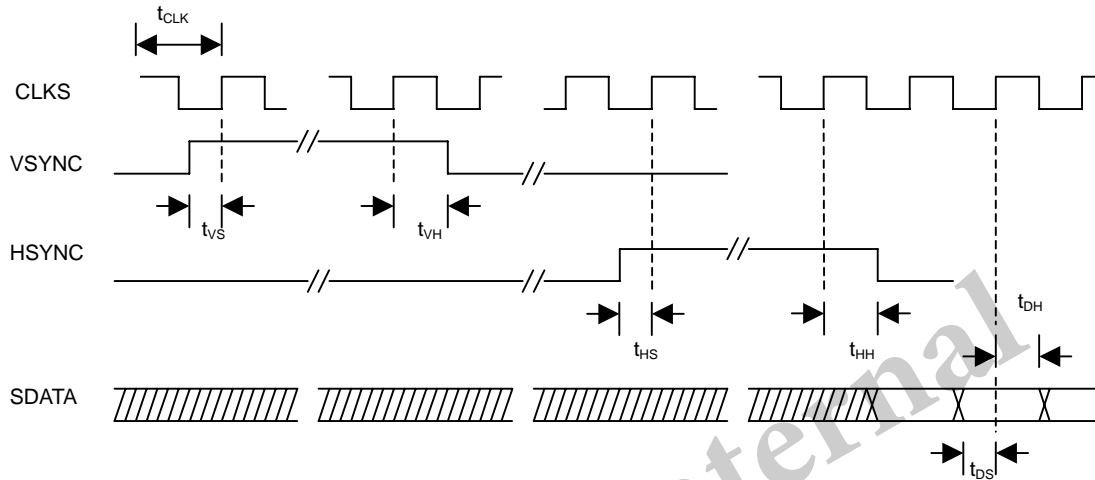
## 7.2 DC Electrical Characteristics

(Under the condition of  $V_{DD}=1.8V$ ,  $V_{DD33}=3.3V$ ,  $T_{OPT}=25^{\circ}C$  if not specified.)

Parameter	Symbol	Min	Typ	Max	Unit
Power supply voltage for I/O	$V_{DD33}$	2.97	3.3	3.63	V
Power supply voltage for core	$V_{DD}$	1.62	1.8	1.98	V
Operation current of $V_{DD33}$	$I_{DD33}$		12.2		mA
Operation current of $V_{DD}$	$I_{DD}$		22.5		mA
Suspend current of $V_{DD33}$	$I_{S33}$		210		$\mu A$
Suspend current of $V_{DD}$	$I_S$		160		$\mu A$
Input high voltage	$V_{IH}$	2.0		5.5	V
Input low voltage	$V_{IL}$	-0.3		0.8	V
Input leakage current	$I_L$			$\pm 10$	$\mu A$
Tri-state output leakage current	$I_{OZ}$			$\pm 10$	$\mu A$
Pull up resistor	$R_{PU}$	39	65	116	Kohm
Pull down resistor	$R_{PD}$	40	56	108	Kohm
Input capacitance	$C_{IN}$		4.37		pF
Output capacitance	$C_{OUT}$		4.37		pF
Output high voltage @ $I_{OH}=8mA$	$V_{OH}$	2.4			V
Output low voltage @ $I_{OL}=8mA$	$V_{OL}$			0.4	V
Output high current @ $V_{OH}=2.4V$ (8mA)	$I_{OH}$	11.2	23.8	38.3	mA
Output high current @ $V_{OH}=2.4V$ (24mA)	$I_{OH}$	33.7	71.5	115.0	mA
Output low current @ $V_{OL}=0.4V$ (8mA)	$I_{OL}$	9.4	15.9	19.8	mA
Output low current @ $V_{OL}=0.4V$ (24mA)	$I_{OL}$	28.3	47.8	59.7	mA
Output Power VO1	$VO_1$			270	mW
Output Power VO2	$VO_2$			465	mW

## 7.3 AC Electrical Characteristics

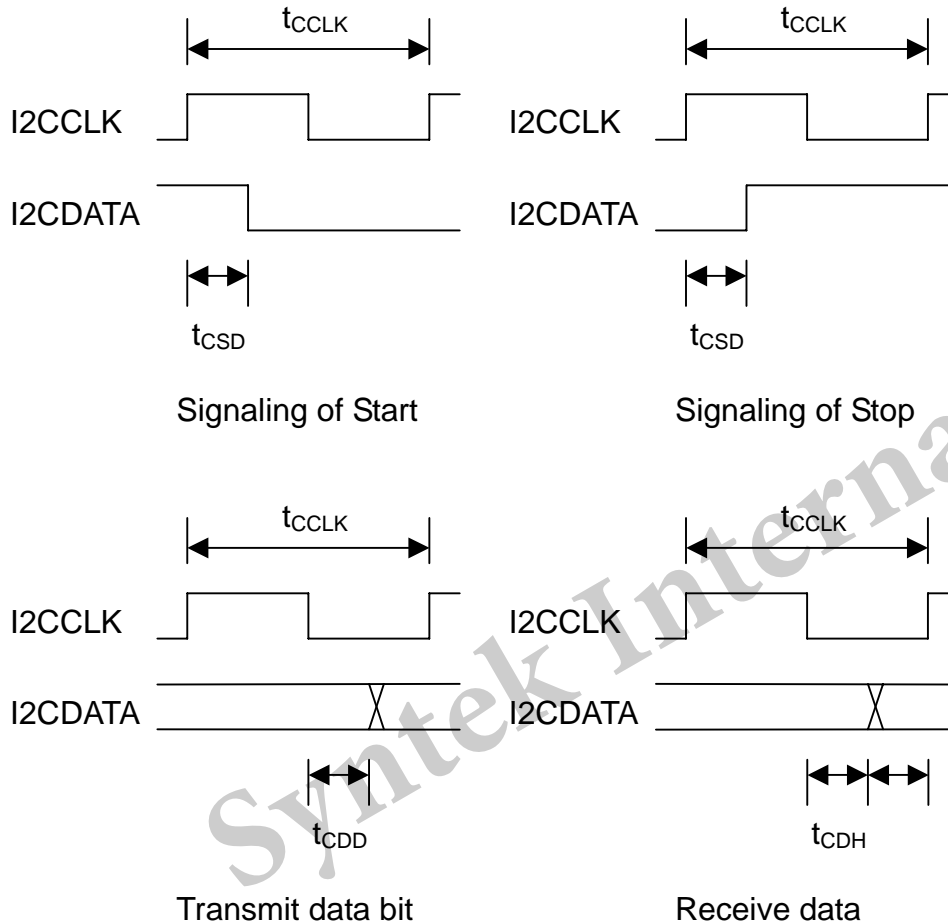
### 7.3.1 Image Sensor Interface



Parameter	Symbol	Min	Typ	Max	Unit
CLKS period	$t_{CLK}$	16			ns
Setup time of $V_{SYNC}$	$t_{VS}$	2			ns
Hold time of $V_{SYNC}$	$t_{VH}$	2			ns
Setup time of $H_{SYNC}$	$t_{HS}$	2			ns
Hold time of $H_{SYNC}$	$t_{HH}$	2			ns
Setup time of SDATA	$t_{DS}$	2			ns
Hold time of SDATA	$t_{DH}$	2			ns



### 7.3.2 Serial Control Interface

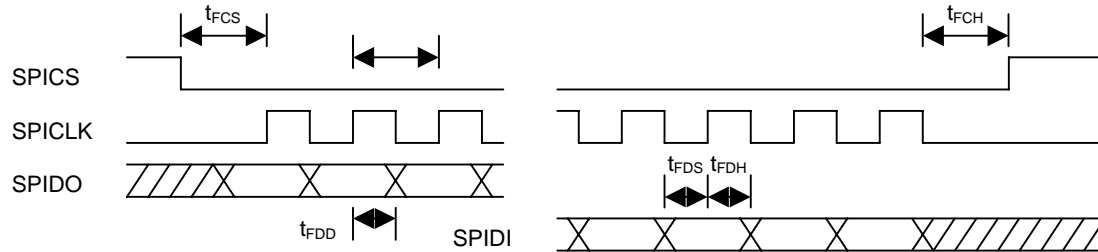


Parameter	Symbol	Min	Typ	Max	Unit
I2CCLK period	$t_{CCLK}$		10000		ns
I2CCLK period (fast I2C)	$t_{CCLK}$		2500		ns
I2CDATA output delay at Start/Stop	$t_{CSD}$	$0.25*t_{CCLK} - 64$	$0.25*t_{CCLK}$	$0.25*t_{CCLK} + 64$	ns
I2CDATA output delay while transmitting	$t_{CDD}$	$0.25*t_{CCLK} - 64$	$0.25*t_{CCLK}$	$0.25*t_{CCLK} + 64$	ns
I2CDATA setup time while receiving	$t_{CDS}$	0			ns
I2CDATA hold time while receiving	$t_{CDH}$	0			ns

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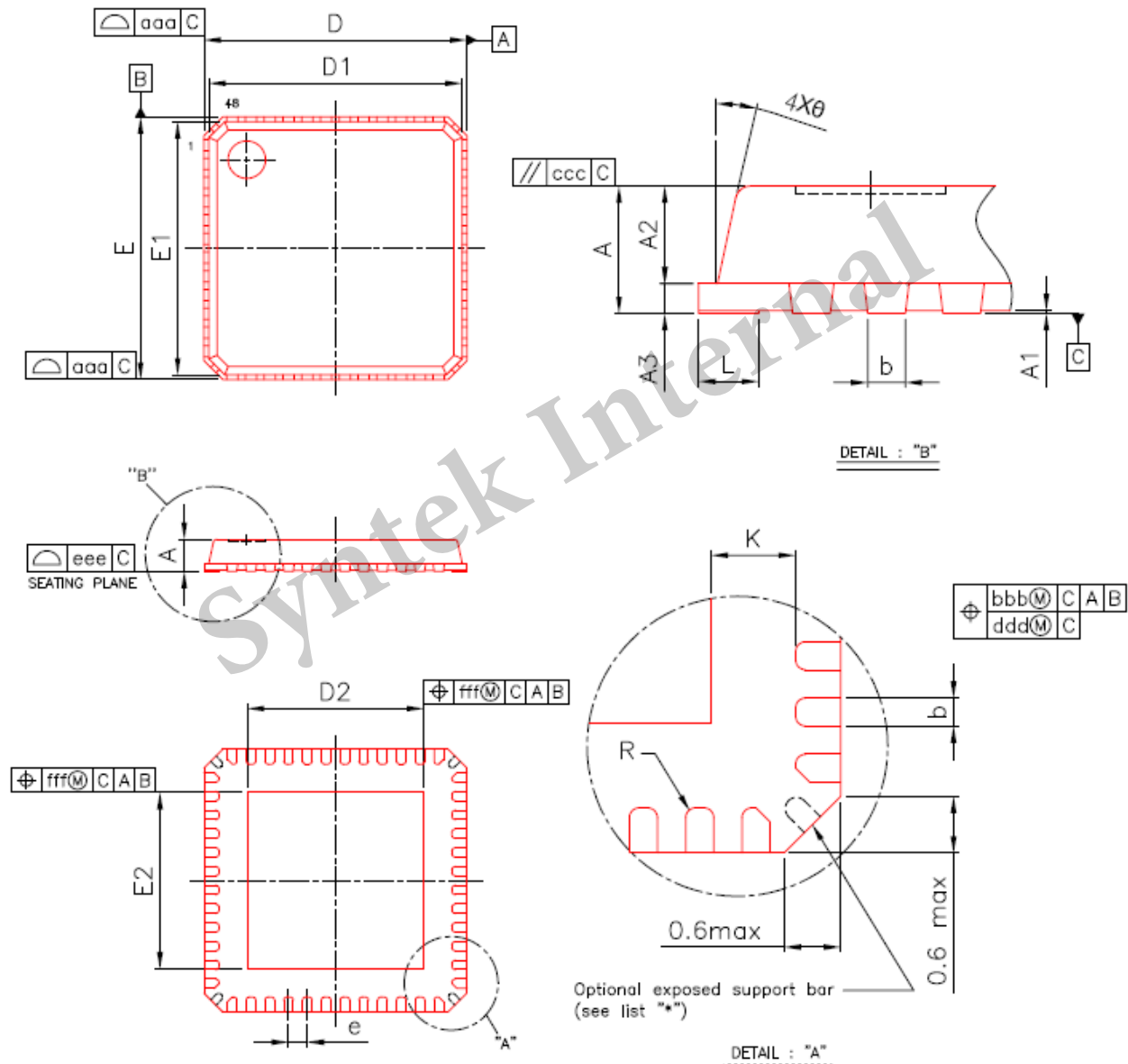
### 7.3.3 Serial Flash Interface



Parameter	Symbol	Min	Typ	Max	Unit
SPICLK period	$t_{FCLK}$		64		ns
SPICS setup time	$t_{FCS}$	64			ns
SPICS hold time	$t_{FCH}$	64			ns
SPIDO output delay	$t_{FDD}$	$0.5 * t_{FCLK} - 2$	$0.5 * t_{FCLK}$	$0.5 * t_{FCLK} + 2$	ns
SPIDI setup time	$t_{FDS}$	2			ns
SPIDI hold time	$t_{FDH}$	2			ns

## 8 Package Dimensions

### 8.1 48-pin LD QFN Package, 6x6x0.85mm



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### 8.1.1 Dimension 6x6x0.85mm

Symbol	Dimension in mm			Dimension in inch		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.85	0.90	0.031	0.033	0.035
A1	0.00	0.02	0.05	0.000	0.001	0.002
A2	0.60	0.65	0.70	0.024	0.026	0.028
A3	0.20 REF			0.008 REF		
b	0.15	0.20	0.25	0.006	0.008	0.010
D/E	6.00 BSC			0.236 BSC		
D1/E1	5.75 BSC			0.226 BSC		
e	0.40 BSC			0.016 BSC		
L	0.30	0.40	0.50	0.012	0.016	0.020
K	0.20	----	----	0.008	----	----
R	0.075	----	----	0.003	----	----
θ	0°	----	14°	0°	----	14°
aaa	----	----	0.10	----	----	0.004
bbb	----	----	0.07	----	----	0.003
ccc	----	----	0.10	----	----	0.004
ddd	----	----	0.05	----	----	0.002
eee	----	----	0.08	----	----	0.003
fff	----	----	0.10	----	----	0.004

NOTE:

1. CONTROLLING DIMENSION : MILLIMETER
2. REFERENCE DOCUMENT: JEDEC MO-220.

L/F	Exposed Pad Size					
	D2/E2 (mm)			D2/E2 (inch)		
	MIN	NOM	MAX	MIN	NOM	MAX
①	4.15	4.30	4.45	0.163	0.169	0.175
②	4.35	4.50	4.65	0.171	0.177	0.183
③	2.95	3.10	3.25	0.116	0.122	0.128
④	3.65	3.80	3.95	0.144	0.150	0.156
⑤	3.95	4.10	4.25	0.156	0.161	0.167
⑥	4.35/4.55	4.50/4.70	4.65/4.85	0.171/0.179	0.177/0.185	0.183/0.191

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## 10 Revision History

Revision	Date	Description
0.9	2008/01/15	Initial release
1.0	2008/05/02	Commercial release
1.1	2008/11/04	Add LDO characters
1.2	2009/09/15	Update platform supports Add AC electrical timing
1.3	2009/09/16	Update maximum acceptable sensor pixel clock Fix typo on LDO description Fix typo on still image capture methods
1.4	2009/10/06	Remove QFN 7x7 package dimension

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