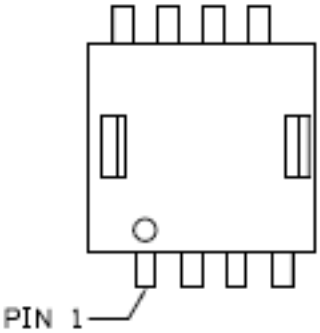
MCS-12085

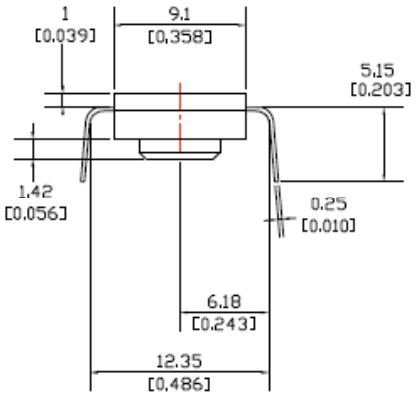
Data Sheet

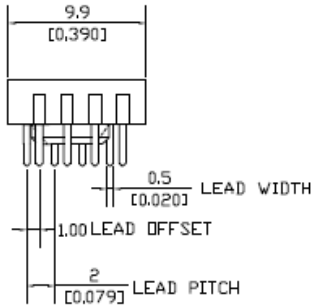
1. Features

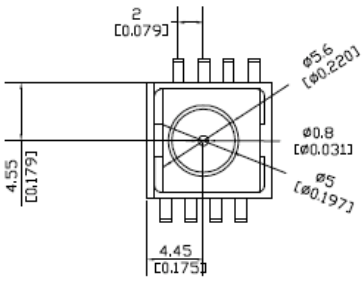
- **Small form factor (10 mm x 12.5 mm footprint)**
- **Complete 2D motion sensor**
- **Common interface for general purpose controller**
- **Smooth surface navigation**
- **Programmable frame speed up to 1500 frames per sec (fps)**
- **Accurate motion up to 12 ips**
- **400 cpi resolution**
- **Wave solderable**
- **Single 5.0 volt power supply**
- **Conforms to USB suspend mode specifications**
- **Power conservation mode during times of no movement**
- **Serial port registers**
  - **Programming**
  - **Data transfer**
- **8-pin staggered dual inline package (DIP)**

2.Product outline









Notes :

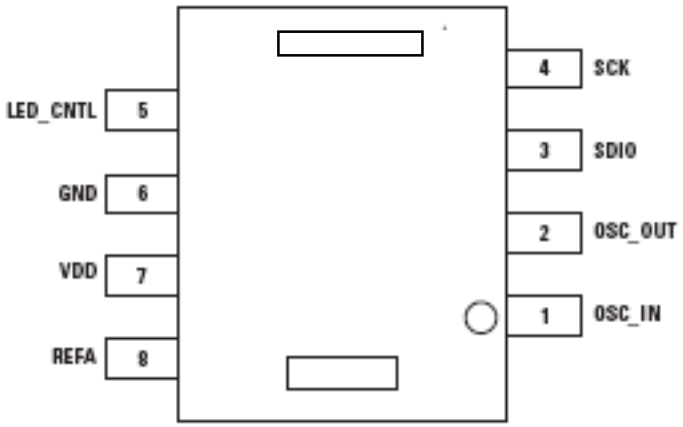
1.Dimensions in milometer / inches

2. Tolerance on numbers :

.xxx ±0.05 .x±0.15

.xx±0.10 .±0.20

3.PinOut of MCS-12085



Pin Number	Pin	Description
1	OSC_IN	Oscillator input
2	OSC_OUT	Oscillator output
3	SDIO	Serial Port Data (input and output)
4	SCK	Serial Port Clock (Input)
5	LED_CNTL	Digital Shutter Signal Out
6	GND	System Ground
7	VDD	5V DC Input
8	REFA	Internal reference

4.Electrical Characteristics

Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units	Notes
Storage Temperature	T_S	-40	85	°C	
Operating Temperature	T_A	-15	55	°C	
Lead Solder Temp			260	°C	For 10 seconds, 1.6 mm below seating plane
Supply Voltage	V_{DD}	-0.5	5.5	V	
ESD			2	KV	All pins, human body model MIL 883 Method 3015
Input Voltage	V_{IN}	-0.5	V_{DD} + 0.5	V	SDIO, CLK, LED_CNTL
Input Voltage	V_{IN}	-0.5	3.6	V	OSC_IN, OSC_OUT, REFA

Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Operating Temperature	T_A	0		40	°C	
Power Supply Voltage	V_{DD}	4.1	5.0	5.5	Volts	Register values retained for voltage transients below 4.10V but greater than 3.9V
Power Supply Rise Time	V_{RT}			100	ms	
Supply Noise	V_N			100	mV	Peak to peak within 0-100 MHz bandwidth
Clock Frequency	f_{CLK}	23.0	24.0	25.0	MHz	Set by ceramic resonator
Serial Port Clock Frequency	SCLK			$f_{CLK}/12$	MHz	
Resonator Impedance	X_{RES}			55	Ω	
Distance from Lens Reference Plane to Surface	Z	2.3	2.4	2.5	mm	Results in ±0.2 mm DOF
Speed	S	0		12	in/sec	@ frame rate = 1500 fps
Acceleration	A			0.25	g	@ frame rate = 1500 fps
Light Level onto IC	IRR_{INC}	80 100		25,000 30,000	mW/m^2	[= 639 nm [= 875 nm
SDIO Read Hold Time	t_{HOLD}	100			∝s	Hold time for valid data
SDIO Serial Write-write Time	t_{SWW}	100			∝s	Time between two write commands
SDIO Serial Write-read Time	t_{SWR}	100			∝s	Time between write and read operation
SDIO Serial Read-write Time	t_{SRW}	250			ns	Time between read and write operation
SDIO Serial Read-read Time	t_{SRR}	250			ns	Time between two read commands
Data Delay after PD deactivated	$t_{COMPUTE}$	3.1			ms	After $t_{COMPUTE}$, all registers contain data from first image after wakeup from Power-Down mode. Note that an additional 75 frames for AGC stabilization may be required if mouse movement occurred while Power Down.
SDIO Write Setup Time	t_{SETUP}	60			ns	Data valid time before the rising of SCLK
Frame Rate	FR			1500	frames/s	

AC Electrical Specifications

Electrical Characteristics over recommended operating conditions. Typical values at 25°C, V_{DD} = 5 V, 24 MHz, 1500 fps.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Power Down (PD)	t_{PD}	1.33			∝s	32 clock cycle minimum after setting bit 6 in the Configuration register.
Power Up after PD mode deactivated	t_{PUPD}			50	ms	From PD mode deactivation to accurate reports 610 ∝s + 75 frames
Power Up from V_{DD} ↑	t_{PU}			40	ms	From V_{DD} to valid accurate reports 610 ∝s + 50 frames
Rise and Fall Times						
SDIO	t_r		30		ns	C_L = 30 pF (the rise time is between 10% to 90%)
	t_f		16		ns	C_L = 30 pF (the fall time is between 10% to 90%)
Serial Port Transaction Timer	t_{SPTT}		90		ms	Serial port will reset if current transaction is not complete within t_{SPTT}
Transient Supply Current	I_{DDT}		20	37	mA	Max supply current during a V_{DD} ramp from 0 to 5.0V with > 500 ∝s rise time. Does not include charging current for bypass capacitors

DC Electrical Specifications

Electrical Characteristics over recommended operating conditions. Typical values at 25°C, V_{DD} = 5 V, 24 MHz, 1500 fps.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current (mouse moving)	$I_{DD\ AVG}$		15	30	mA	
Supply Current (mouse not moving)	I_{DD}		12		mA	
Power Down Mode Current	I_{DDPD}		170	230	µA	
SCK pin						
Input Low Voltage	V_{IL}			0.8	V	
Input High Voltage	V_{IH}	2.0			V	
Input Capacitance	C_{IN}			10	pF	
Input Resistance	R_{IN}	1			MΩ	
SDIO pin						V_{DD}=4 V, Load = 50 pF, 80n s rise & fall
Input Low Voltage	V_{IL}			0.8	V	
Input High Voltage	V_{IH}	2.0			V	
Output Low Voltage	V_{OL}			0.5	V	
Output High Voltage	V_{OH}	0.8 * V_{DD}			V	
Drive Low Current	I_L	2.0			mA	
Drive High Current	I_H	2.0			mA	
Input Capacitance	C_{IN}			10	pF	
Input Resistance	R_{IN}	1			MΩ	
LED_CNTL pin						
Output Low Voltage	V_{OL}			0.1	V	
Output High Voltage	V_{OH}	0.8 * V_{DD}			V	
Drive Low Current	I_L	250			µA	
Drive High Current	I_H	250			µA	
OSC_IN						
Input Resistance	R_{IN}		500		kΩ	
Input Capacitance	C_{IN}		15		pF	
Input High Voltage	V_{IH}	2.2			V	External clock source
Input Low Voltage	V_{IL}			0.8	V	External clock source

6.Synchronous Serial Port

The synchronous serial port is used to set and read parameters in the MCS-12085, and also to read out the motion information.

The port is a two wire, half duplex port. The host microcontroller always initiates communication; the MCS-12085 never initiates data transfers.

SCK The serial port clock. It is always generated by the master (the microcontroller).

SDIO The data line.

Write Operation

Write operations, where data is going from the microcontroller to the MCS-12085, is always initiated by the microcontroller and consists of two bytes. The first byte contains the address (seven bits) and has a "1" as its MSB to indicate data direction. The second byte contains the data. The transfer is synchronized by SCK. The microcontroller changes SDIO on falling edges of SCK. The MCS-12085 reads SDIO on rising edges of SCK.(see the Figure A,B)

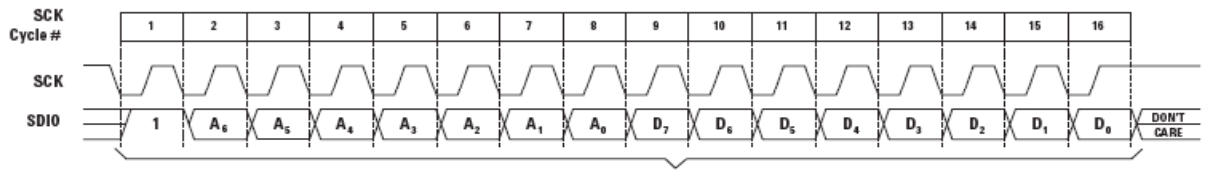


Figure A SDIO driven by microcontroller

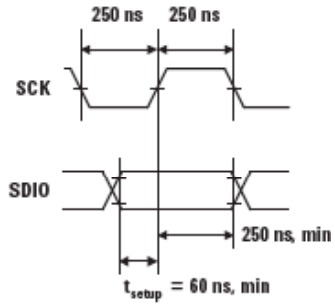


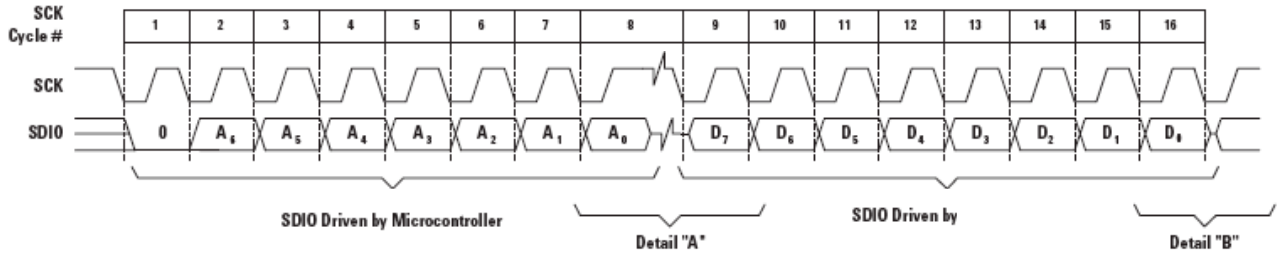
Figure B SDIO setup and hold times SCK pulse width

7.Functions

Read Operation

A read operation, meaning data that is going from the MCS-12085 to the microcontroller, is always initiated by the microcontroller and consists of two bytes. The first byte that contains the address is written by the microcontroller and has a “0” as its MSB to indicate data direction. The second byte contains the data and is driven by the MCS-12085. The transfer is synchronized by SCK. SDIO is changed on falling edges of **SCK** and read on every rising edge of SCK. The microcontroller must go to a High-Z state after the last address data bit.

The IC will go to the High-Z state after the last data bit. Another thing to note during a read operation is that SCK needs to be delayed after the last address data bit to ensure that the IC has at least 100 □s to prepare the requested data. This is shown in the timing diagrams below .(Figure C,D)



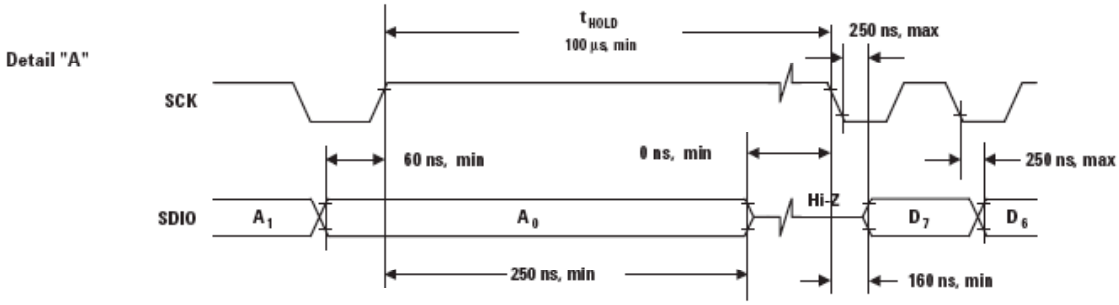


Figure C Microcontroller to MCS-12085 SDIO hand off

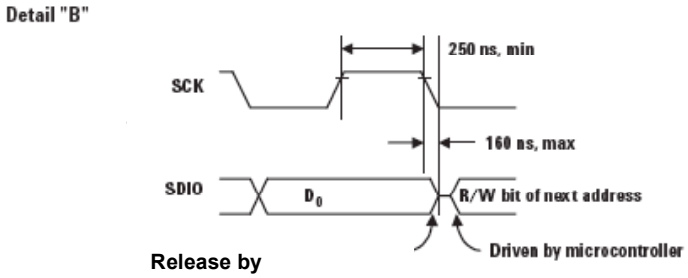


Figure D MCS-12085 to Microcontroller hand off

Forcing the SDIO Line to the Hi-Z state

There are times when the SDIO line from the MCS-12085 should be in the Hi-Z state. For example, if the microprocessor has completed a write to the MCS-12085, the SDIO line will go into a Hi-Z state, because the SDIO pin was configured as an input. However, if the last operation from the microprocessor was a read, the MCS-12085 will hold the D0 state on SDIO until a falling edge of SCK.

To place the SDIO pin into a Hi-Z state, activate the power-down mode by writing to the configuration register. Then, the power down mode can stay activated, with the MCS-12085 in the shutdown state, or the power- down mode can be deactivated, returning the MCS-12085 to normal operation. In both conditions, the SDIO line will go into the Hi-Z state.
invalid address

Another method to put the SDIO line into the Hi-Z state, while the MCS-12085 at normal mode, is to write any data to an invalid address such as 0x00 to address 0x77. The SDIO line will go into the Hi-Z state after the write operations.

Power-down Mode (PD) and Timing

MCS-12085 can be placed in a power-down mode by setting bit 6 in the configuration register via a serial I/O port write operation. Note that while writing a “1” to bit 6 of the configuration register, all other bits must be written with their original value in order to keep the current configuration. After setting the configuration register, wait at least 32 system clock cycles. To get the chip out of the power-down mode, clear bit 6 in the configuration register via a serial I/O port write operation.

Otherwise, the sensor may go into a hang-up state). While the sensor is in power-down mode, only the bit 6 data will be written to the configuration register. Writing the other configuration register values will not have any effect. For an accurate report after power-up, wait for a total period of 50 ms before the microcontroller is able to issue any write/read operation to the MCS-12085. The sensor register settings, prior to power-down mode, will remain during power- down mode. (See Figure E,F))

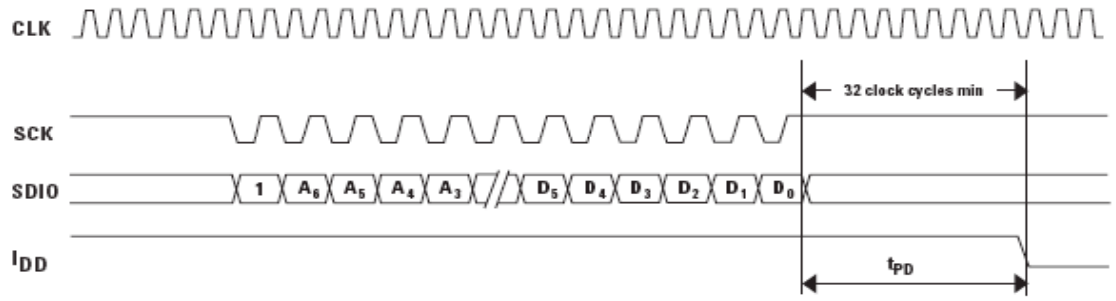


Figure E Power timing

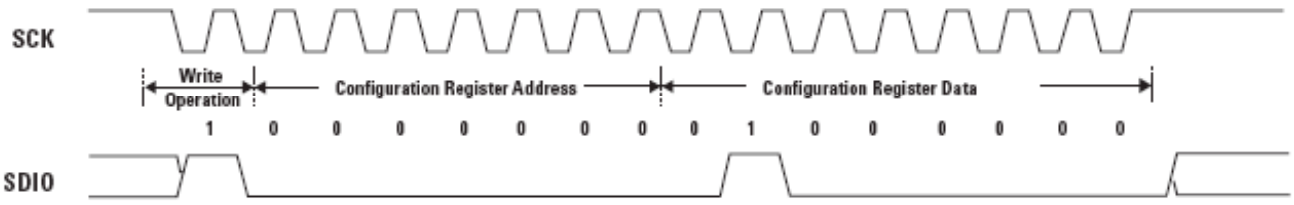


Figure F Power down configuration register writing operation

Setting the power down bit simply sets the analog circuitry into a no current state.
Note: LED_CNTL, and SDIO will be tri-stated during power down mode.

Required Timing between Read and Write Commands (tsxx)

There are minimum timing requirements between read and write commands on the serial port.

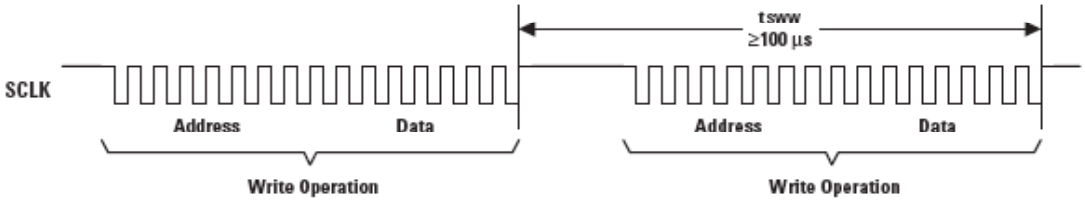


Figure G Timing between two commands

If the rising edge of the SCK for the last data bit of the second write command occurs before the 100 µs required delay, then the first write command may not complete correctly.

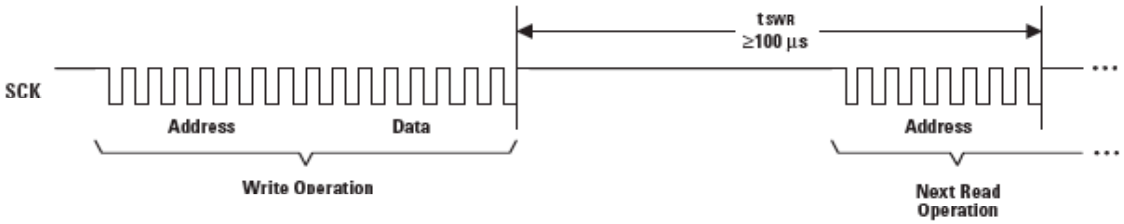


Figure H Timing between writes and read command

If the rising edge of SCK for the last address bit of the read command occurs before the 100 µs required delay, then the write command may not complete correctly.

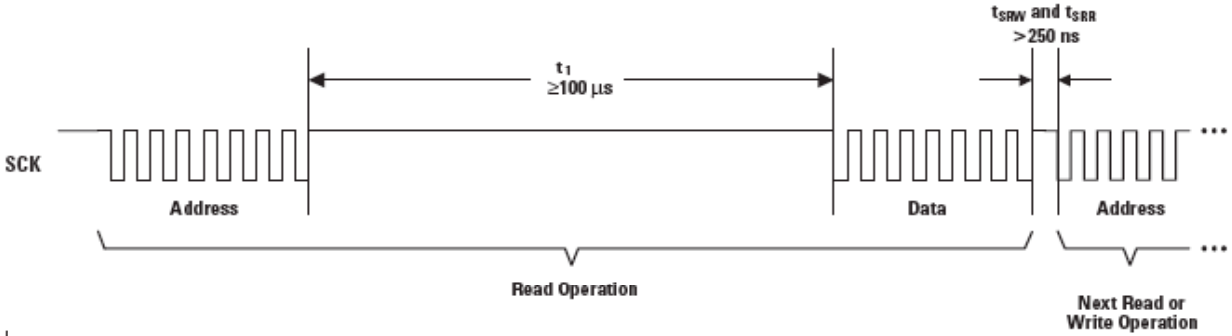


Figure I Time between read and either write or subsequent read commands

The falling edge of SCK for the first address bit of either the read or write command must be at least 250 ns after the last SCK rising edge of the last data bit of the previous read operation.

8.Programming Guide Registers

The MCS-12085 can be programmed through registers, via the serial port, and configuration and motion data can be read from these registers

Register	Address	Notes
Configuration	0x00	Reset, Power Down, Forced Awake, etc
Status	0x01	Product ID, Mouse state of Asleep or Awake
Delta_Y	0x02	Y Movement
Delta_X	0x03	X Movement
SQUAL	0x04	Measure of the number of features visible by the sensor
Maximum_Pixel	0x05	
Minimum_Pixel	0x06	
Pixel_Sum	0x07	
Pixel Data	0x08	Actual picture of surface
Shutter_Upper	0x09	
Shutter_Lower	0x0A	
Inverse Product	0x11	Inverse Product ID

Configuration Address: 0x00
Access: Read/Write Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0

Data Type: Bit field

USAGE: The Configuration register allows the user to change the configuration of the sensor. Shown below are the bits, their default values, and optional values.

Field Name	Description
C_7	Reset **0 = No effect** 1 = Reset the part
C_6	Power down **0 = Normal operation** 1 = power down all analog circuitry
C_5 _ C_1	Reserved
C_0	Forced Awake Mode **0 = Normal, fall asleep after one second of no movement (1500 frames/ s)** 1 = Always awake

Status Address: 0x01
Access: Read Reset Value: 0x01

Bit	7	6	5	4	3	2	1	0
Field	ID_2	ID_1	ID_0	Reserved	Reserved	Reserved	Reserved	Awake

Data Type: Bit Field

USAGE: Status information and type of mouse sensor, current state of the mouse.

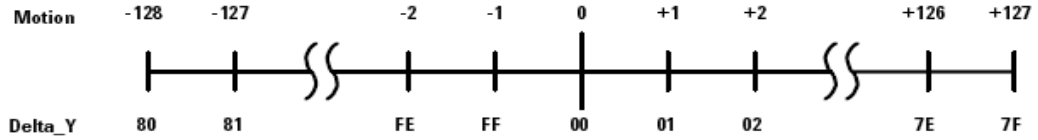
Field Name	Description
ID_2 _ ID_0	Product ID (000 for ADNS-2610)
Reserved	Reserved for future
Awake	Mouse State **0 = Asleep** 1 = Awake

Delta_Y Address: 0x02
Access: Read Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0

Data Type: Eight bit 2's complement number.

USAGE: Y movement is counted since last report. Absolute value is determined by resolution. Reading clears the register.

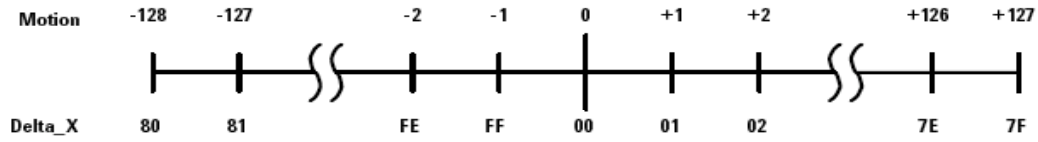


Delta_X Address: 0x03
Access: Read Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	X_7	X_6	X_5	X_4	X_3	X_2	X_1	X_0

Data Type: Eight bit 2's complement number.

USAGE: X movement is counted since last report. Absolute value is determined by resolution. Reading clears the register



SQUAL
Access: Read

Address: 0x04
Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	SQ_7	SQ_6	SQ_5	SQ_4	SQ_3	SQ_2	SQ_1	SQ_0

Data Type: Upper 8 bits of a 9-bit integer.

USAGE: SQUAL (Surface QUALity) is a measure of the number of features visible by the sensor in the current frame.

Number of Features = SQUAL Register Value x 2.

Maximum_Pixel
Access: Read

Address: 0x05
Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	0	0	MP_5	MP_4	MP_3	MP_2	MP_1	MP_0

Data Type: Six bit number.

USAGE: Maximum Pixel value in current frame. Minimum value = 0, maximum value = 63. The maximum pixel value may vary from frame to frame. Shown below is a graph of 250 sequentially acquired maximum pixel values, while the sensor was moved slowly over white paper.

Minimum_Pixel
Access: Read

Address: 0x06
Reset Value: 0x3f

Bit	7	6	5	4	3	2	1	0
Field	0	0	MP_5	MP_4	MP_3	MP_2	MP_1	MP_0

Data Type: Six bit number.

USAGE: Minimum Pixel value in current frame. Minimum value = 0, maximum value = 63. The minimum pixel value may vary from frame to frame.

Pixel_Sum Address: 0x07
Access: Read Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	PS_7	PS_6	PS_5	PS_4	PS_3	PS_2	PS_1	PS_0

Data Type: Upper 8 bits of a 15-bit unsigned integer.

USAGE: This register is used to find the average pixel value. It reports the upper 8 bits of a 15-bit unsigned integer, which sums all 324 pixels in the current frame. It may be described as the full sum divided by 128. The formula to calculate the average pixel value is as below:

Average Pixel = Register Value x 128 / 324

= Pixel_Sum x 0.395

The maximum register value is 159 (63 x 324 / 128 truncated to an integer). The minimum is 0. The pixel sum value may vary from frame to frame.

Pixel Data Address: 0x08
Access: Read/Write Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	SOF	Data_Valid	PD_5	PD_4	PD_3	PD_2	PD_1	PD_0

Data Type: Two status bits, six bit pixel data.

USAGE: Digital Pixel data. Minimum value = 0, maximum value = 63. Any writes to this register resets the pixel hardware so that the next read from the Pixel Data register will read pixel #1 and the StartOfFrame bit will be set. Subsequent reads will auto increment the pixel number.

To dump a complete image, set the LED to forced awake mode, write anything to this register, then read 324 times where the DataValid bit is set. On the 325th read, the StartOfFrame bit will be set indicating that we have completed one frame of pixels and are starting back at pixel 1.

It takes at least 324 frames to complete an image as we can only read 1 pixel per frame.

The pixel hardware is armed with any read or write to the Pixel Data register and will output pixel data from the next available frame. So, if you were to write the Pixel Data register, wait 5 seconds then read the Pixel Data register; the reported pixel data was from 5 seconds ago.

Field Name	Description
SOF	Start of Frame **0 = Not start of frame** 1 = Current pixel is number 1, start of frame
Data_Valid	There is valid data in the frame grabber
PD_5 – PD_0	Six bit pixel data

Shutter_Upper Address: 0x09
Access: Read Reset Value: 0x01

Bit	7	6	5	4	3	2	1	0
Field	S_{15}	S_{14}	S_{13}	S_{12}	S_{11}	S_{10}	S_9	S_8

Shutter_Lower Address: 0x0A
Access: Read Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	S_7	S_6	S_5	S_4	S_3	S_2	S_1	S_0

Data Type: Sixteen bit word.

USAGE: Units are clock cycles; default value is $0x0100_{HEX}$. Read Shutter_Upper first, then Shutter_Lower. They should be read consecutively. The sensor adjusts the shutter to keep the average and maximum pixel values within normal operating ranges. The shutter value may vary with every frame. Each time the shutter changes, it changes by ±1/16 of the current value.

The maximum value of the shutter is dependent upon the clock frequency. The formula for the maximum shutter value is:

$$\text{Max shutter value} = \frac{\text{clock freq}}{1500} - 3476$$

For a clock frequency of 24 MHz, the following table shows the maximum shutter value. 1 clock cycle is 41.67 nsec.

Frames/second	Max Shutter		Shutter		
	Decimal	Hex	Upper	Lower	
1512	12397	0x306D	30	6D	← Default Max Shutter

Inverse_Product Address: 0x11
Access: Read Reset Value: 0xFF

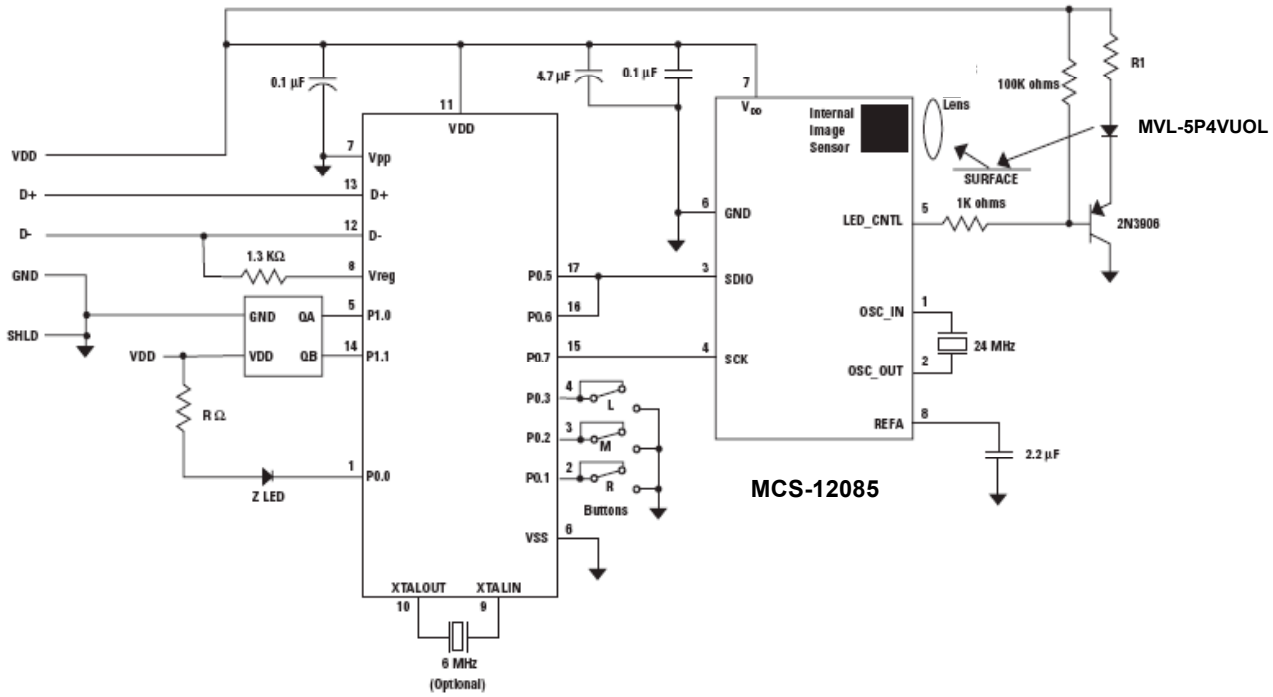
Bit	7	6	5	4	3	2	1	0
Field	Reserved	Reserved	Reserved	Reserved	IP_3	IP_2	IP_1	IP_0

Data Type: 4 bit number.

USAGE: Status information and type of mouse sensor

Field name	Description
Reserved	Reserved for future use
IP_3-IP_0	Inverse Product ID (x1111b or xFh)

Application Circuit



Notes on PCB Layout

- Caps for pins 6,7 and 8 to ground *MUST* have trace lengths *LESS* than 5 mm
- The 0.1 uF caps must be ceramic.
- Caps should have less than 5 nH of self inductance
- Caps should have less than 0.2 ohms ESR

Regulatory Requirement

- Surface mount parts are recommended
- Passes FCC B and worldwide analogous emission limits when assembled into a mouse with unshielded cable.
- Passes EN61000-4-4/IEC801-4 EFTB tests when assembled into a mouse with shielded cable and following.