

ADNS-5090

Low Power Optical Mouse Sensor



Data Sheet



Description

The Avago Technologies ADNS-5090 is a low power, small form factor optical mouse sensor. It has a low-power architecture and automatic power management modes, making it ideal for battery, power-sensitive applications – such as cordless input devices.

The ADNS-5090 is capable of high-speed motion detection – up to 30ips and 8G. In addition, it has an on-chip oscillator and LED driver to minimize external components.

The ADNS-5090 along with the ADNS-5110-001 lens, LED clip, and HLMP-EG3E-xxxxx LED form a complete and compact mouse tracking system. There are no moving parts and this translates to high reliability and less maintenance for the end user. In addition, precision optical alignment is not required, facilitating high volume assembly.

The sensor is programmed via registers through a four-wire serial port. It is housed in an 8-pin staggered dual in-line package (DIP).

NOTE: The ADNS-5090 Low Power Optical Mouse Sensor is not designed for use with blue LEDs. The ADNS-4000 product is available from Avago for use with Blue LEDs.

Features

- Low Power Architecture
- Small Form Factor
- Programmable Periods / Response Times and Downshift Times from one mode to another for the Power-saving Modes
- ‘Smart’ LED Current Switching depending on surface brightness
- High Speed Motion Detection up to 30ips and 8G
- External Interrupt Output for Motion Detection
- Internal Oscillator – no clock input needed
- Selectable Resolution up to 1750cpi
- Operating Voltage: as low as 2.8V
- Four wire Serial Port Interface
- Minimal number of passive components

Applications

- Optical mice and optical trackballs
- Integrated input devices
- Battery-powered input devices

Theory of Operation

The ADNS-5090 is based on Optical Navigation Technology, which measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the direction and magnitude of movement.

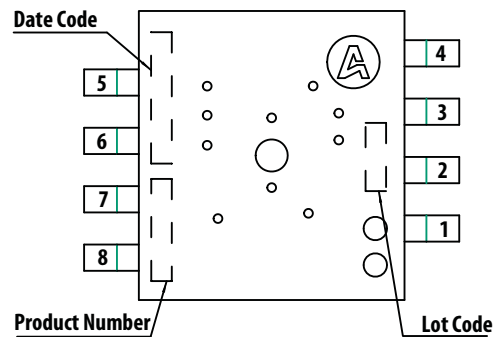
The ADNS-5090 contains an Image Acquisition System (IAS), a Digital Signal Processor (DSP), and a four wire serial port.

The IAS acquires microscopic surface images via the lens and illumination system. These images are processed by the DSP to determine the direction and distance of motion. The DSP calculates the Dx and Dy relative displacement values.

An external microcontroller reads and translates the Dx and Dy information from the sensor serial port into PS2, USB, or RF signals before sending them to the host PC.

Pinout of ADNS-5090 Optical Mouse Sensor

| Pin | Name | Input/Output | Description |
|-----|--------|--------------|--|
| 1 | MISO | O | Serial Data Output (Master In/ Slave Out) |
| 2 | LED | O | LED Illumination |
| 3 | MOTION | O | Motion Interrupt Output (Default active low) |
| 4 | NCS | I | Chip Select (Active low input) |
| 5 | SCLK | I | Serial Clock |
| 6 | GND | Gnd | Ground |
| 7 | VDD | Power | Supply Voltage |
| 8 | MOSI | I | Serial Data Input (Master Out/ Slave In) |



| Item | Marking | Remarks |
|----------------|---------|--|
| Product Number | A5090 | |
| Date Code | XYWWZ | X = Subcon Code YYWW = Date Code Z = Sensor Die Source |
| Lot Code | VVV | Numeric |

Figure 1. Package outline drawing (top view)

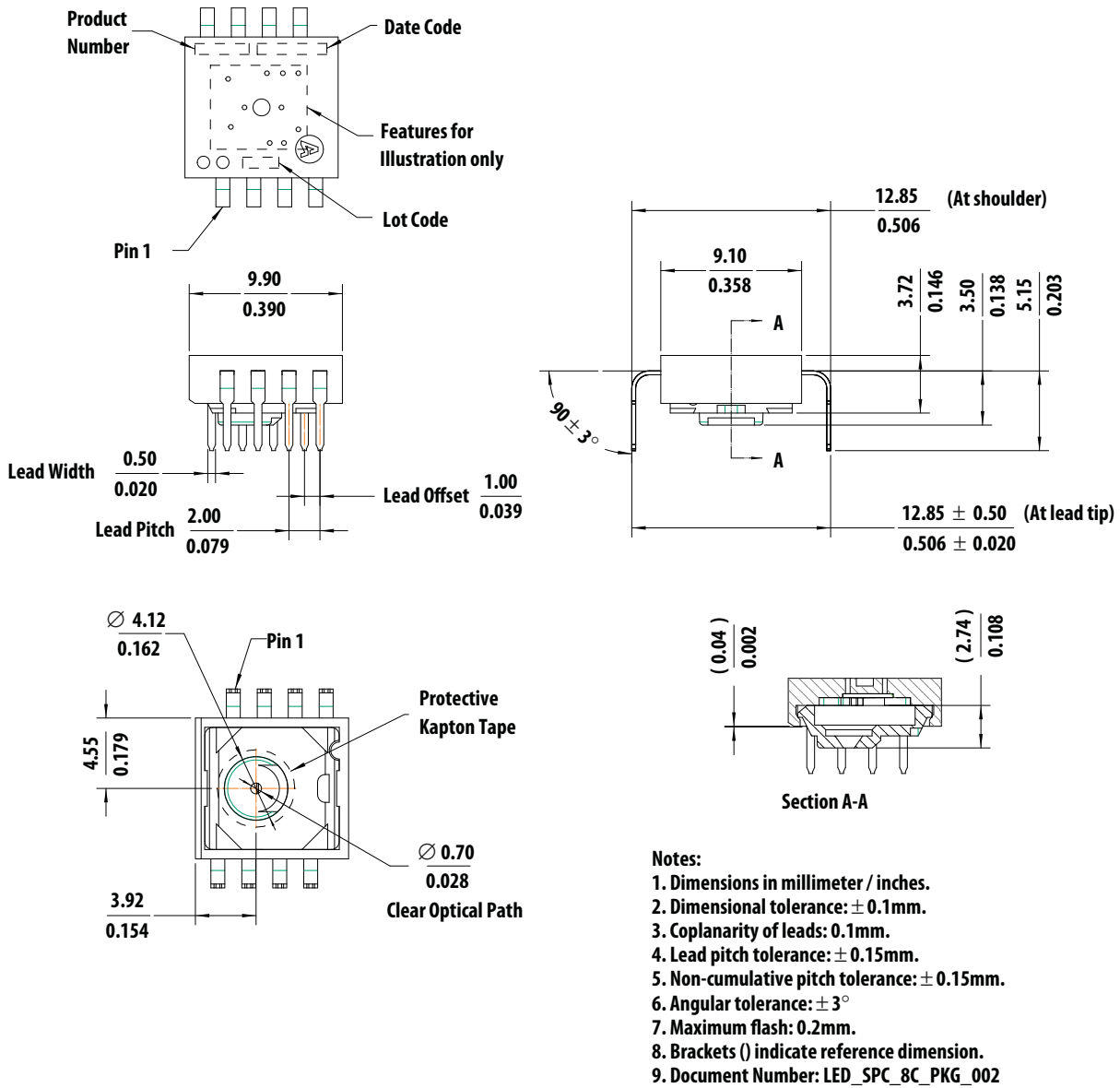


Figure 2. Package Outline Drawing

CAUTION: It is advised that normal static precautions be taken in handling and assembling of this component to prevent damage and/or degradation which may be induced by ESD.

Overview of Optical Mouse Sensor Assembly

Avago Technologies provides an IGES file drawing describing the base plate molding features for lens and PCB alignment. The ADNS-5090 sensor is designed for mounting on a through-hole PCB. There is an aperture stop and features on the package that align to the lens. The ADNS-5110-001 lens provides optics for the imaging of the surface as well as illumination of the surface at the optimum angle. Features on the lens align it to the sensor, base plate, and clip with the LED. The LED clip holds the LED in relation to the lens. The LED must be inserted into the clip and the LED's leads formed prior to loading on the PCB.

The HLMP-EG3E-xxxxx LED is recommended for illumination.

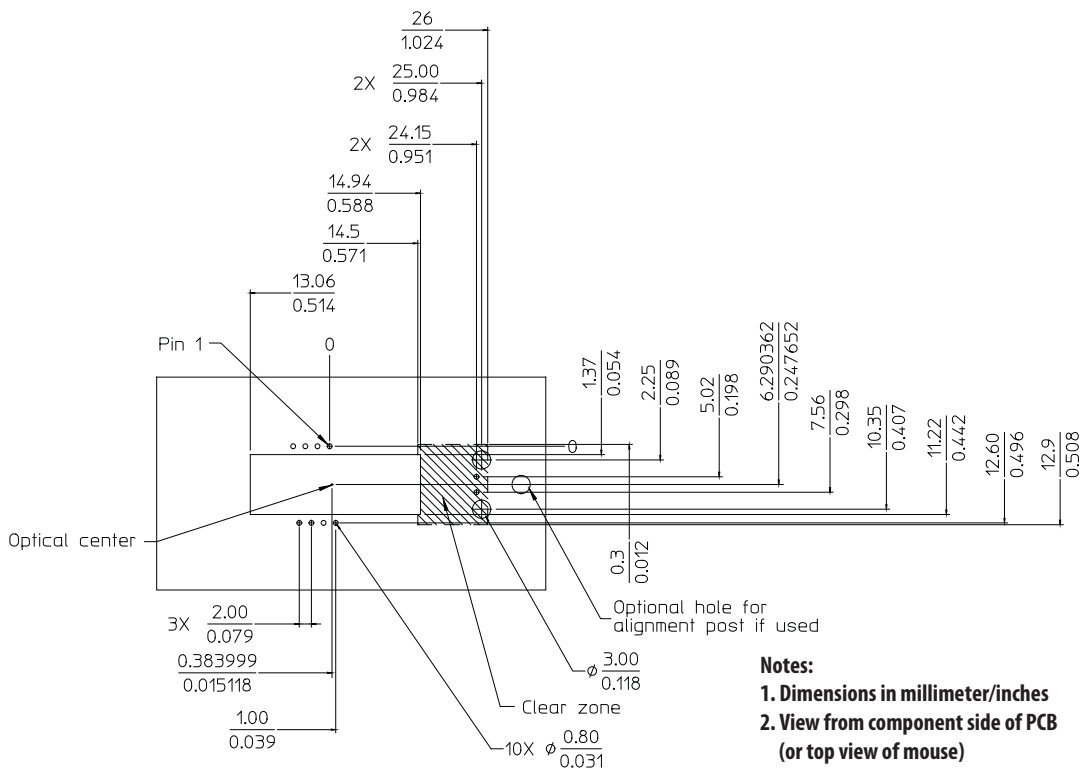
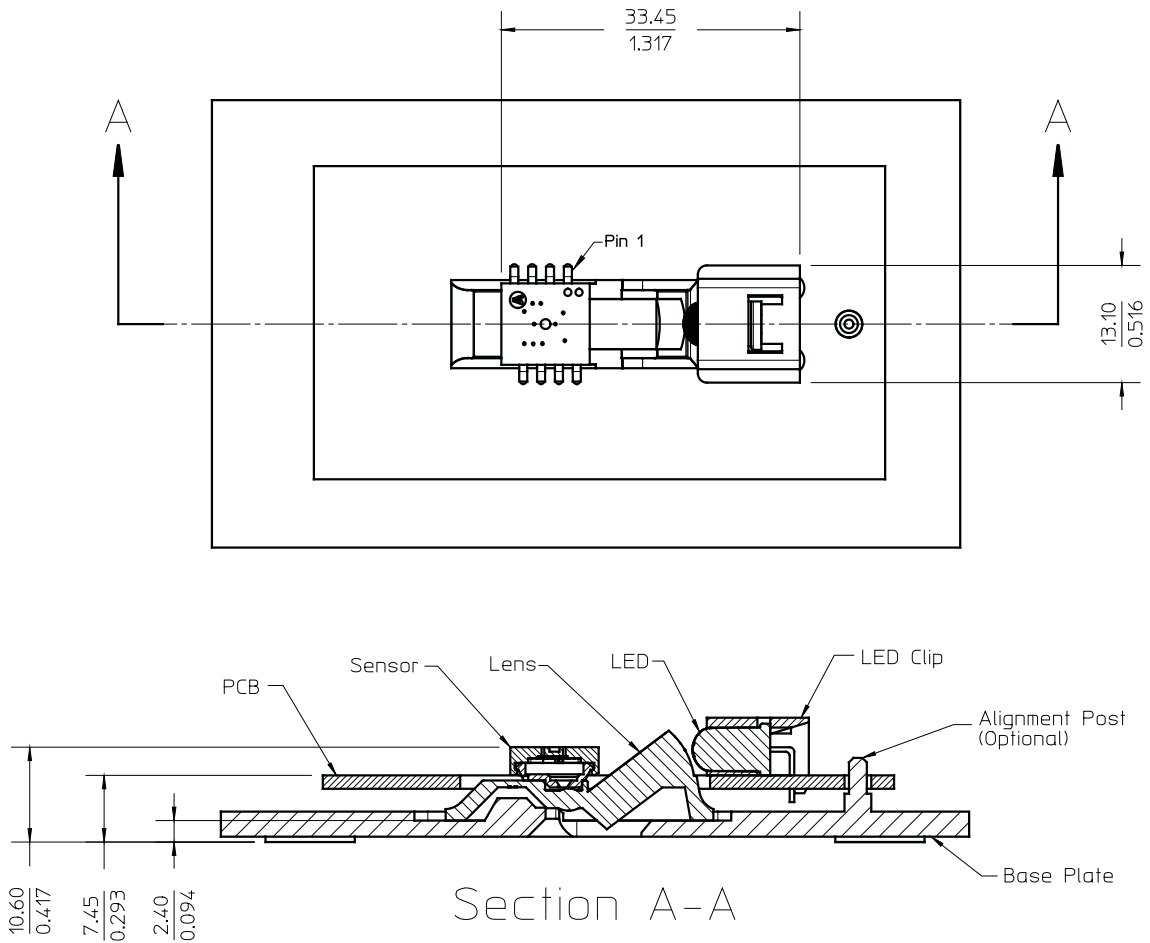
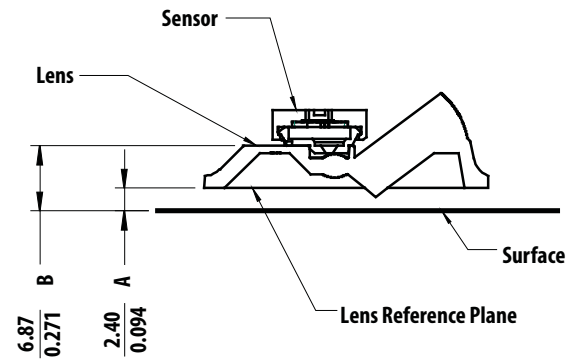


Figure 3. Recommended PCB Mechanical Cutouts and Spacing (Top View)



Important Note: Pin 1 of sensor should be located nearest to the LED

Figure 4. 2D Assembly drawing of ADNS-5090 (Top and Side View)



Note:

A – Distance from object surface to lens reference plane

B – Distance from object surface to sensor reference plane

Figure 5. Distance from lens reference plane to tracking surface (Z)

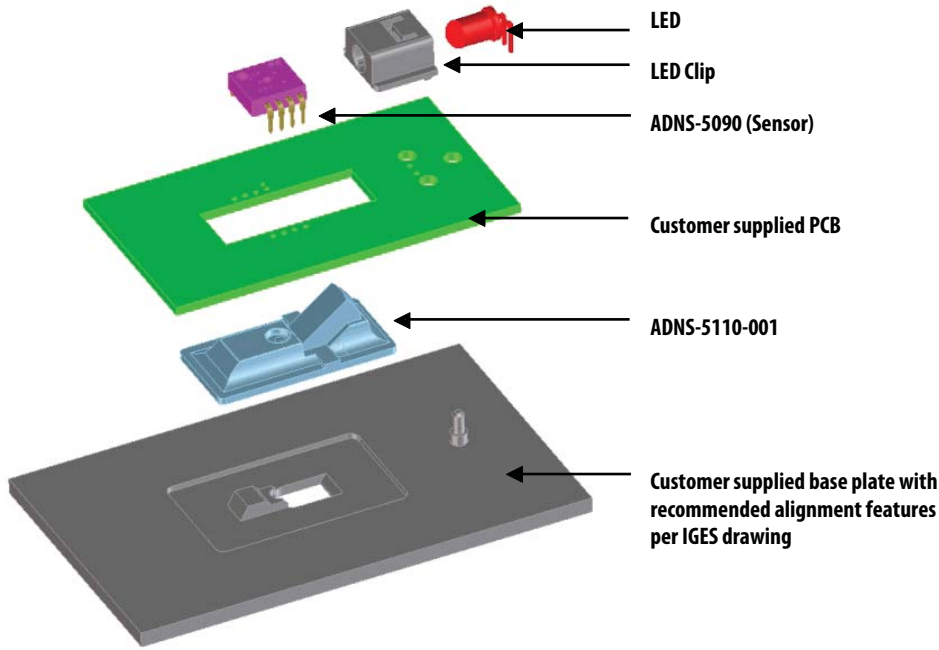


Figure 6. Exploded View of Assembly

PCB Assembly Considerations

1. Insert the sensor and all other electrical components into PCB.
2. Insert the LED into the assembly clip and bend the leads 90 degrees.
3. Insert the LED clip assembly into PCB.
4. This sensor package is only qualified for wave-solder process.
5. Wave solder the entire assembly in a no-wash solder process utilizing solder fixture. The solder fixture is needed to protect the sensor during the solder process. It also sets the correct sensor-to-PCB distance as the lead shoulders do not normally rest on the PCB surface. The fixture should be designed to expose the sensor leads to solder while shielding the optical aperture from direct solder contact.
6. Place the lens onto the base plate.
7. Remove the protective kapton tape from optical aperture of the sensor. Care must be taken to keep contaminants from entering the aperture. Recommend not to place the PCB facing up during the entire mouse assembly process. Recommend to hold the PCB first vertically for the kapton removal process.
8. Insert PCB assembly over the lens onto the base plate aligning post to retain PCB assembly. The sensor aperture ring should self-align to the lens.
9. The optical position reference for the PCB is set by the base plate and lens. Note that the PCB motion due to button presses must be minimized to maintain optical alignment.
10. Install mouse top case. There MUST be a feature in the top case to press down onto the PCB assembly to ensure all components are interlocked to the correct vertical height.

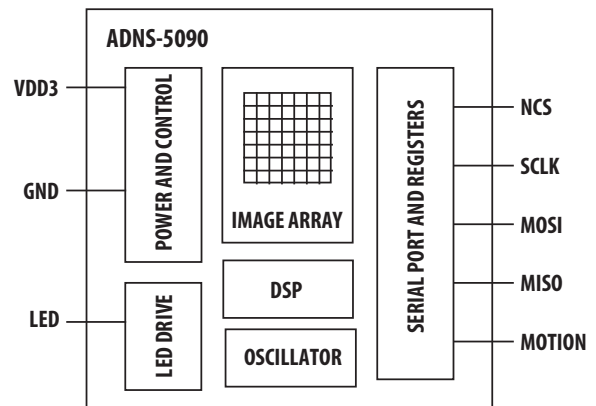


Figure 7. Block diagram of ADNS-5090 optical mouse

Recommended Typical Application (Receiver Side)

Recommended Typical Application (Transmitter Side)

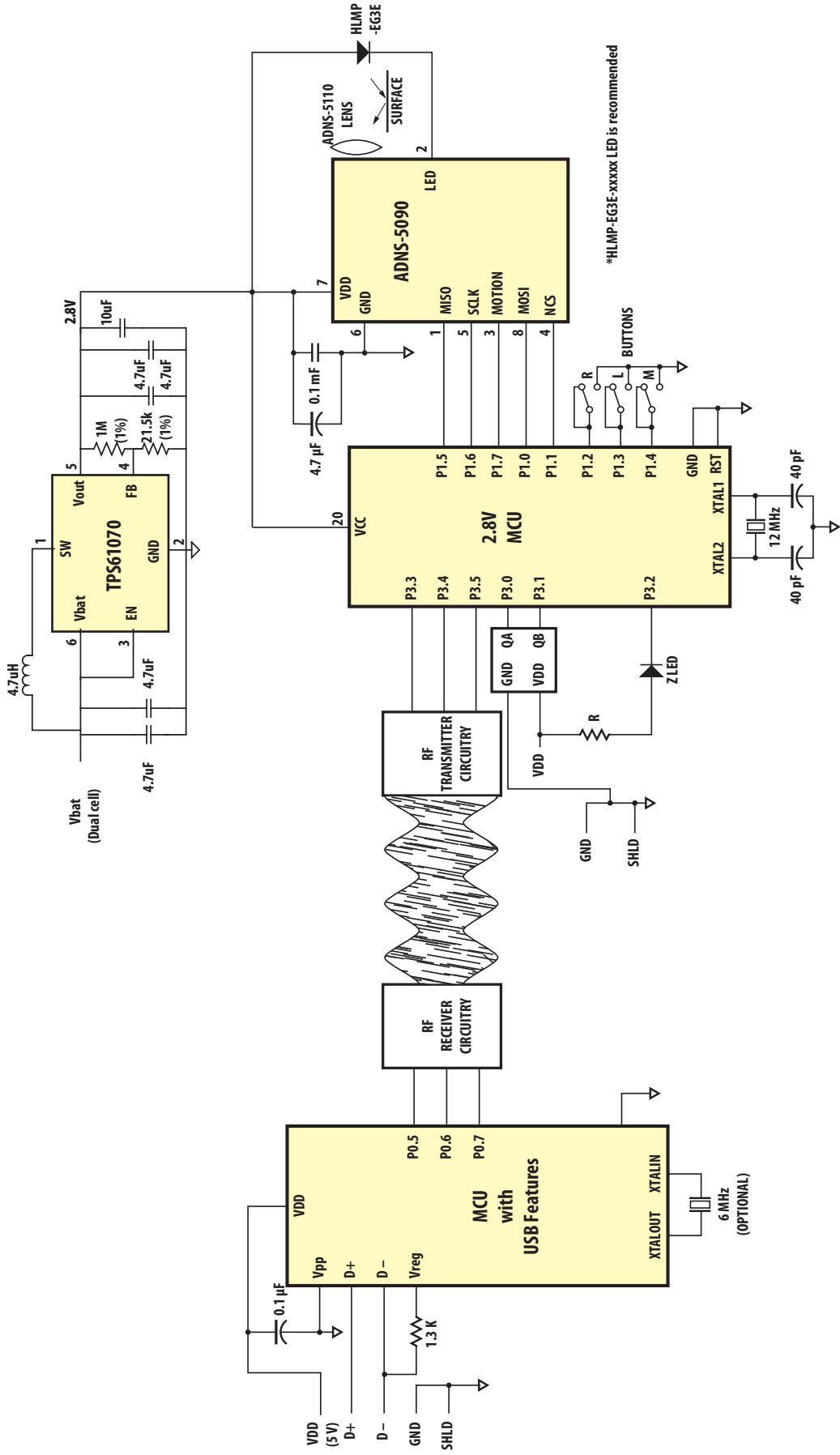


Figure 8a. Schematic diagram for interface between ADNS-5090 and microcontroller with HLMP-EG3E-xxxxx LED (cordless application)

Note:
The ADNS-5090 Low Power Optical Mouse Sensor is not designed for use with blue LEDs. The ADNS-4000 product is available from Avago for use with Blue LEDs.

Recommended Typical Application (Receiver Side)

Recommended Typical Application (Transmitter Side)

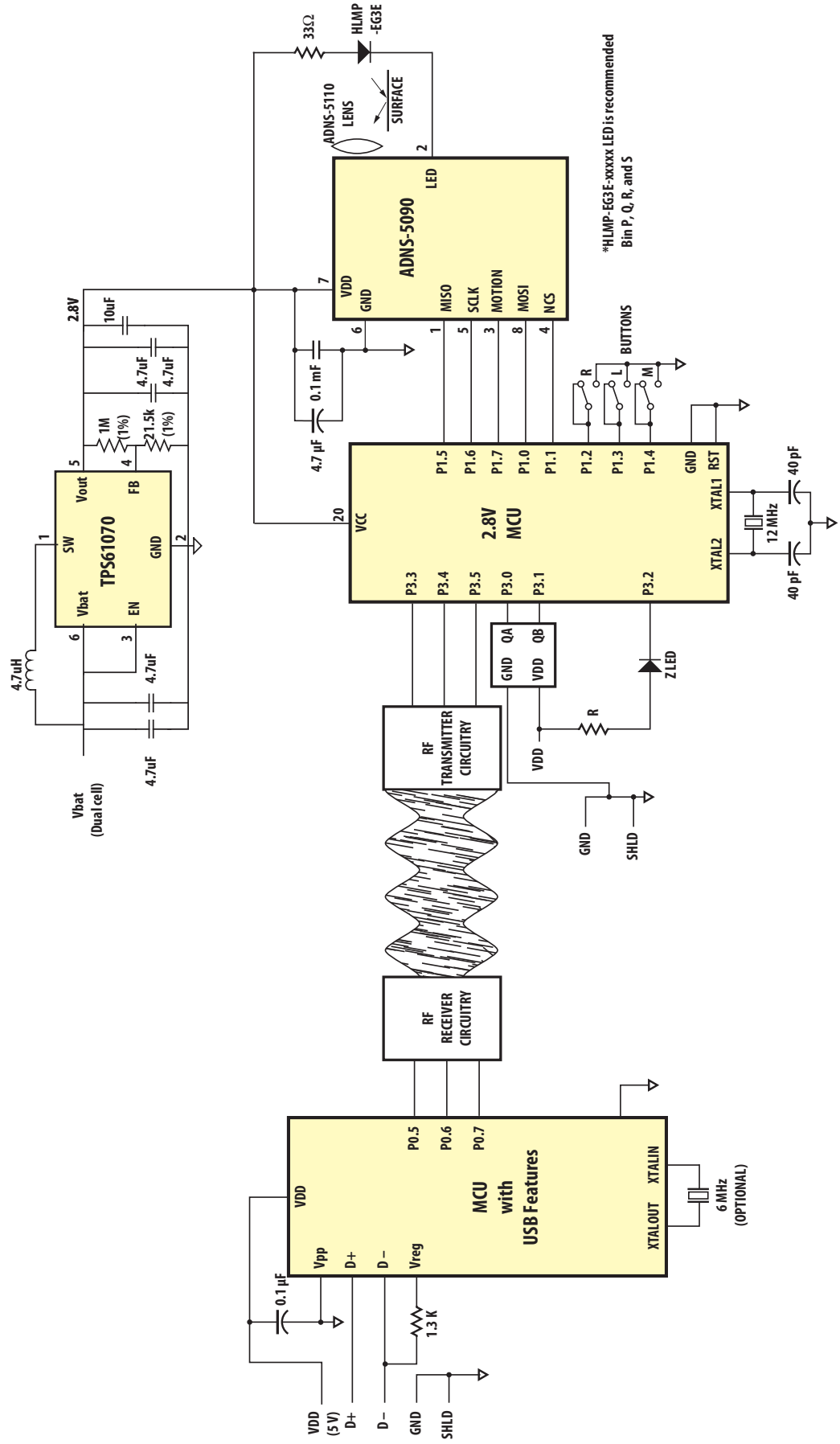


Figure 8b. Schematic diagram for interface between ADNS-5090 and microcontroller with HLMP-EG3E-xxxxx LED (cordless application)

Note: The ADNS-5090 Low Power Optical Mouse Sensor is not designed for use with blue LEDs. The ADNS-4000 product is available from Avago for use with Blue LEDs.

Design Considerations for Improved ESD Performance

For improved electrostatic discharge performance, typical creepage and clearance distance are shown in the table below. Assumption: base plate construction is as per the Avago Technologies supplied IGES file and ADNS-5110-001 lens. Note that the lens material is polycarbonate or polystyrene HH30. Therefore, cyanoacrylate based adhesives or other adhesives that may damage the lens should NOT be used.

| Typical Distance (mm) ADNS-5110-001 | |
|--|-------|
| Creepage | 15.43 |
| Clearance | 7.77 |

Regulatory Requirements

- Passes FCC B and worldwide analogous emission limits when assembled into a mouse with shielded cable and following Avago Technologies recommendations.
- Passes IEC-1000-4-3 radiated susceptibility level when assembled into a mouse with shielded cable and following Avago Technologies recommendations.
- UL flammability level UL94 HB.

Table 1. 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 Temperature | | | 260 | °C | For 7 seconds, 1.6mm below seating plane. |
| Supply Voltage | V_{DD} | -0.5 | 3.7 | V | |
| ESD (Human Body Model) | | | 2 | kV | All pins |
| Input Voltage | V_{IN} | -0.5 | $V_{DD} + 0.5$ | V | All I/O pins |
| Output Current | I_{out} | | 7 | mA | MISO pin |

Table 2. Recommended Operating Condition

| Parameter | Symbol | Min | Typ. | Max | Units | Notes |
|--|------------|-------|------|-----|-------|-----------------------|
| Operating Temperature | T_A | 0 | | 40 | °C | |
| Power Supply Voltage | V_{DD} | 2.8 | | 3.0 | V | |
| Power Supply Rise Time | T_{RT} | 0.005 | | 100 | ms | 0 to VDD min |
| Supply Noise (Sinusoidal) | V_{NA} | | | 100 | mVp-p | 10kHz – 50MHz |
| Serial Port Clock Frequency | f_{SCLK} | | | 1 | MHz | 50% duty cycle |
| Distance from Lens Reference Plane to Tracking Surface (Z) | Z | 2.3 | 2.4 | 2.5 | mm | |
| Speed | S | 0 | | 30 | ips | At default frame rate |
| Acceleration | a | | | 8 | G | At run mode |
| Load Capacitance | C_{out} | | | 100 | pF | MISO |

Table 3. AC Electrical Specifications

Electrical characteristics over recommended operating conditions. Typical values at 25 °C, VDD = 2.8 V.

| Parameter | Symbol | Min. | Typ. | Max. | Units | Notes |
|---|--------------------------------------|------|------|---------------------|-------|--|
| Motion Delay after Reset | t _{MOT-RST} | | | 50 | ms | From RESET register write to valid motion |
| Forced Rest Enable | t _{REST-EN} | | | 1 | s | From Rest Mode(RM) bits set to target rest mode |
| Wake from Forced Rest | t _{REST-DIS} | | | 1 | s | From Rest Mode(RM) bits cleared to valid motion |
| Power Down | t _{PD} | | | 50 | ms | From PD active (when bit 1 of register 0x0d is set) to low current |
| Wake from Power Down | t _{WAKEUP} | 50 | | 55 | ms | From PD inactive (when write 0x5a to register 0x3a) to valid motion |
| MISO Rise Time | t _{r-MISO} | | 40 | 200 | ns | C _L = 100 pF |
| MISO Fall Time | t _{f-MISO} | | 40 | 200 | ns | C _L = 100 pF |
| MISO Delay after SCLK | t _{DLY-MISO} | | | 120 | ns | From SCLK falling edge to MISO data valid, no load conditions |
| MISO Hold Time | t _{hold-MISO} | 500 | | 1/f _{SCLK} | ns | Data held until next falling SCLK edge |
| MOSI Hold Time | t _{hold-MOSI} | 200 | | | ns | Amount of time data is valid after SCLK rising edge |
| MOSI Setup Time | t _{setup-MOSI} | 120 | | | ns | From data valid to SCLK rising edge |
| SPI Time between Write Commands | t _{SWW} | 30 | | | μs | From rising SCLK for last bit of the first data byte, Commands to rising SCLK for last bit of the second data byte |
| SPI Time between Write and Read Commands | t _{SWR} | 20 | | | μs | From rising SCLK f or last bit of the first data byte, to rising SCLK for last bit of the second address byte |
| SPI Time between Read and Subsequent Commands | t _{SRW} t _{SRR} | 250 | | | ns | From rising SCLK for last bit of the first data byte, to falling SCLK for the first bit of the next address |
| SPI Read Address-Data Delay | t _{SRAD} | 4 | | | μs | From rising SCLK for last bit of the address byte, to falling SCLK for first bit of data being read |
| NCS Inactive after Motion Burst | t _{BEXIT} | 250 | | | ns | Minimum NCS inactive time after motion burst before next SPI usage |
| NCS to SCLK Active | t _{NCS-SCLK} | 120 | | | ns | From NCS falling edge to first SCLK falling edge |
| SCLK to NCS Inactive (for Read Operation) | t _{SCLK-NCS} | 120 | | | ns | From last SCLK rising edge to NCS rising edge, for valid MISO data transfer |
| SCLK to NCS Inactive (for Write Operation) | t _{SCLK-NCS} | 20 | | | μs | From last SCLK rising edge to NCS rising edge, for valid MOSI data transfer |
| NCS to MISO high-Z | t _{NCS-MISO} | | | 250 | ns | From NCS rising edge to MISO high-Z state |
| Transient Supply Current | I _{DDT} | | | 60 | mA | Max supply current during a VDD ramp from 0 to VDD |

Table 4. DC Electrical Specifications

Electrical characteristics over recommended operating conditions. Typical values at 25 °C, VDD = 2.8 V.

| Parameter | Symbol | Min | Typ. | Max | Units | Notes |
|-----------------------------------|-----------------------|----------------------|-------|-------|-------|--|
| DC Supply Current in Various Mode | I _{DD_AVG} | | 8.23 | 20.41 | mA | Average run current, including LED current, at max frame rate. No load on MISO |
| | I _{DD_REST1} | | 0.79 | 1.65 | mA | |
| | I _{DD_REST2} | | 0.08 | 0.18 | mA | |
| | I _{DD_REST3} | | 0.026 | 0.054 | mA | |
| Power Down Current | | | 10 | | μA | |
| Input Low Voltage | V _{IL} | | | 0.5 | V | SCLK, MOSI, NCS |
| Input High Voltage | V _{IH} | V _{dd} -0.5 | | | V | SCLK, MOSI, NCS |
| Input Hysteresis | V _{I_HYS} | | 200 | | mV | SCLK, MOSI, NCS |
| Input leakage current | I _{leak} | | ±1 | ±10 | μA | V _{in} =V _{DD} -0.6V, SCLK, MOSI, NCS |
| Output Low Voltage | V _{OL} | | | 0.7 | V | I _{out} =1mA, MISO, MOTION |
| Output High Voltage | V _{OH} | V _{dd} -0.7 | | | V | I _{out} =-1mA, MISO, MOTION |
| Input Capacitance | C _{in} | | 50 | | pF | MOSI, NCS, SCLK |

Typical Performance Characteristics

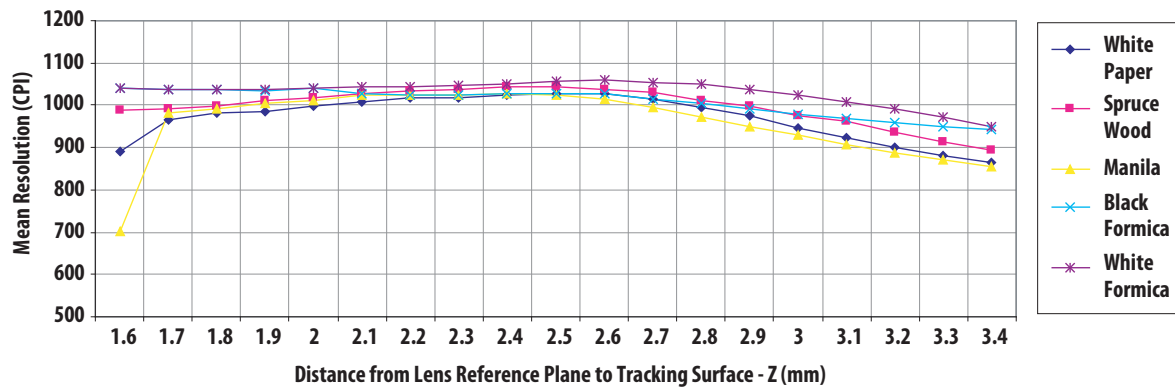


Figure 9. Typical path deviation.

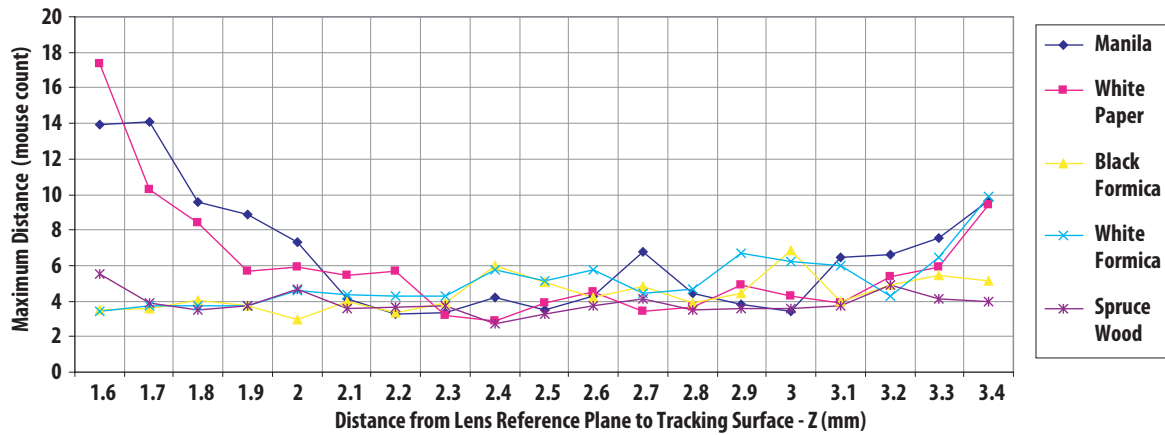


Figure 10. Mean resolution vs. distance from lens reference plane to surface.

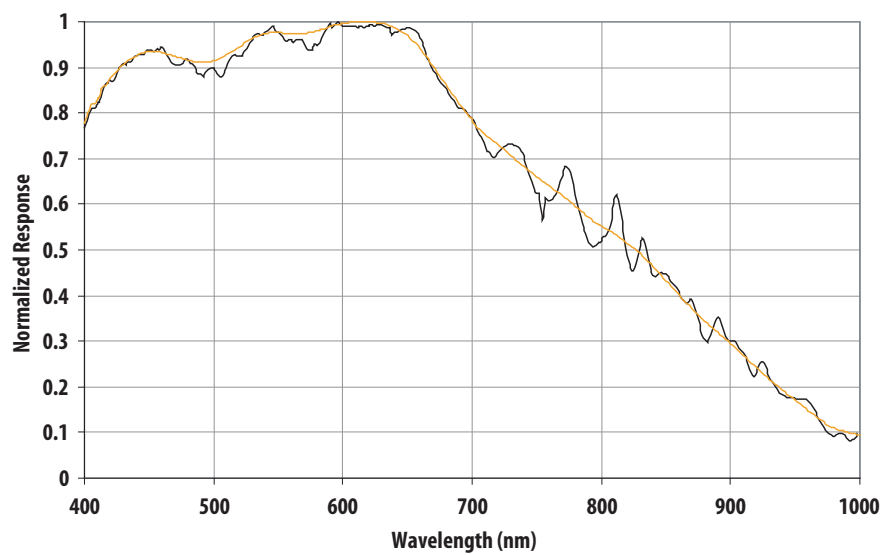


Figure 11. Relative wavelength responsivity.

Synchronous Serial Port

The synchronous serial port is used to set and read parameters in the ADNS-5090, and to read out the motion information. The port is a four wire serial port. The host micro-controller always initiates communication; the ADNS-5090 never initiates data transfers. SCLK, MOSI, and NCS may be driven directly by a micro-controller. The port pins may be shared with other SPI slave devices. When the NCS pin is high, the inputs are ignored and the output is at tri-state.

The lines that comprise the SPI port:

SCLK: Clock input. It is always generated by the master (the micro-controller).

MOSI: Input data. (Master Out/Slave In)

MISO: Output data. (Master In/Slave Out)

NCS: Chip select input (active low). NCS needs to be low to activate the serial port; otherwise, MISO will be high Z, and MOSI & SCLK will be ignored. NCS can also be used to reset the serial port in case of an error.

Chip Select Operation

The serial port is activated after NCS goes low. If NCS is raised during a transaction, the entire transaction is aborted and the serial port will be reset. This is true for all transactions. After a transaction is aborted, the normal address-to-data or transaction-to-transaction delay is still required before beginning the next transaction. To improve communication reliability, all serial transactions should be framed by NCS. In other words, the port should not remain enabled during periods of non-use because ESD and EFT/B events could be interpreted as serial communication and put the chip into an unknown state. In addition, NCS must be raised after each burst-mode transaction is complete to terminate burst-mode. The port is not available for further use until burst-mode is terminated.

'Smart' LED Current Switching

ADNS-5090 is designed with 'smart' LED feature, an auto or self-adjusting LED current switching between the low and high current settings depending on the brightness of the tracking surface. If the surface is sufficiently bright to the sensor, lower LED current will be selected. When tracking on a darker surface, the higher current setting will be used. This feature is one of the power saving features in this sensor controlled by AUTO_LED_CTRL register (0x43).

Power Management Modes

The ADNS-5090 has three power-saving modes. Each mode has a different motion detection period with its respective response time to mouse motion. Response Time is the time taken for the sensor to 'wake up' from rest mode when motion is detected. When left idle, the sensor automatically changes or downshift from Run mode to Rest1, to Rest2 and finally to Rest3 which consumes the least current. Do note that current consumption is the lowest at Rest3 and highest at Rest1, however time required for sensor to respond to motion from Rest1 is the shortest and longest from Rest3. Downshift Time is the elapsed time (under no motion condition) from current mode to the next mode for example, it takes 10s for the sensor that is in Rest1 to change to Rest2. The typical response time and downshift time for each mode is shown in the following table. However, user can change the default time setting for each mode via register 0x0e through 0x13.

| Mode | Response Time (Typical) | Downshift Time (Typical) |
|--------|-------------------------|--------------------------|
| Rest 1 | 10ms | <1s |
| Rest 2 | 100 ms | 9s |
| Rest 3 | 500 ms | 430s |

Another feature in ADNS-5090 that can be used to optimize the power consumption of the optical mouse system is the Motion Interrupt Output or MOTION pin (pin 3). It allows the host controller to be in sleep mode (or lowest operating current mode) when there is no motion detected after some time instead of consistently be in active mode and polling motion data from the sensor. When motion is detected, the sensor will send the motion interrupt signal through pin 3 to the controller to wake it up from sleep mode to resume its motion detection routine for navigation position and direction update.

MOTION Detection Routine

Typically in the motion detection routine, MCU will poll the sensor for valid motion data by checking on the MOTION_ST bit in MOTION_ST register. If MOTION_ST bit is set, motion data in DELTA_X and DELTA_Y is valid and ready to be read by the MCU.

MOTION Function

MOTION output signal (pin 3) can be used as interrupt input to the microcontroller of the mouse to trigger the controller to read the motion data from the sensor whenever there is motion detected by the sensor. The MOTION signal can be configured to be level or edge triggered, active high or low by setting the bits in MOTION_CTRL register.

For active high level-triggered configuration, the MOTION pin level will be driven high as long the MOTION bit in register 0x02 is set and there is motion data in DELTA_X and DELTA_Y registers ready to be read by the microcontroller. Once all the motion data has been read, DELTA_X and DELTA_Y values become zero, MOTION bit is reset and the MOTION pin level is driven low.

For active high edge-triggered configuration, a pulse of 230us will be sent through the MOTION pin when there is motion detected by the sensor during rest modes. The pulse can be used as interrupt input to activate the microcontroller from its sleep mode to enter into run mode to start polling the sensor for motion data by monitoring MOTION_ST bit (set whenever there is valid motion data) in MOTION register (0x02) and reading DELTA_X and DELTA_Y registers until MOTION_ST bit is reset.

Write Operation

Write operation, defined as data going from the micro-controller to the ADNS-5090, is always initiated by the micro-controller and consists of two bytes. The first byte contains the address (seven bits) and has a "1" as its MSB to indicate write sequence. The second byte contains the data. The ADNS-5090 reads MOSI on rising edges of SCLK.

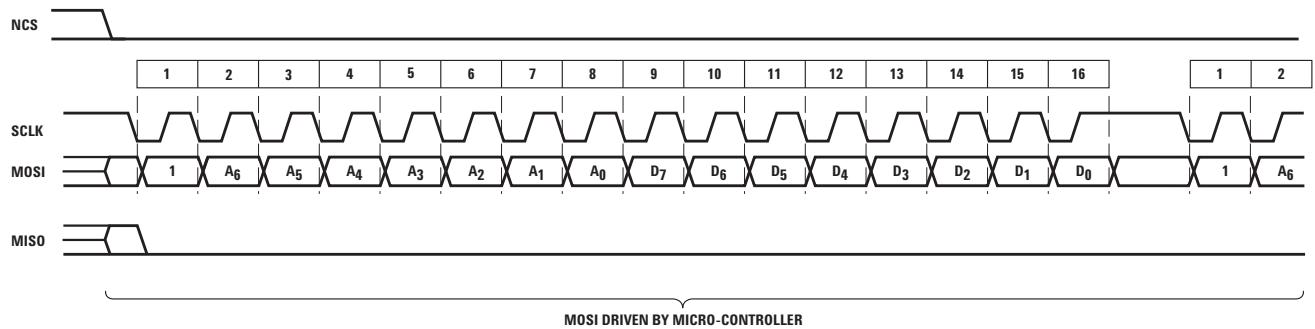


Figure 12. Write Operation

MOSI setup and hold time during write operation

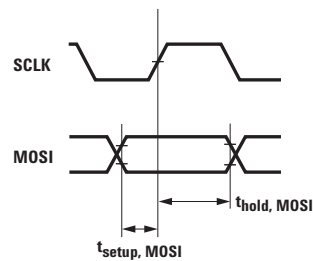


Figure 13. MOSI setup

Read Operation

A read operation, defined as data going from the ADNS-5090 to the micro-controller, is always initiated by the micro-controller and consists of two bytes. The first byte contains the address, is sent by the micro-controller over MOSI, and has a "0" as its MSB to indicate data direction. The second byte contains the data and is driven by the ADNS-5090 over MISO. The sensor outputs MISO bits on falling edges of SCLK and samples MOSI bits on every rising edge of SCLK.

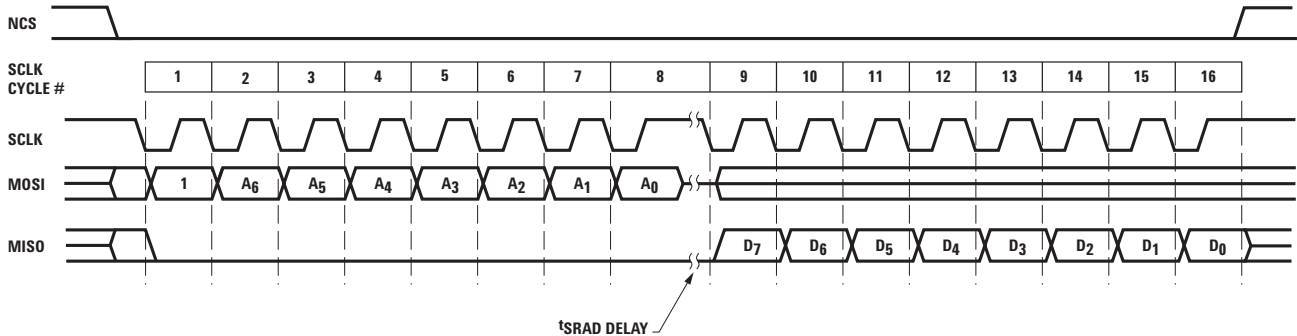


Figure 14. Read Operation

MOSI delay and hold time during read operation

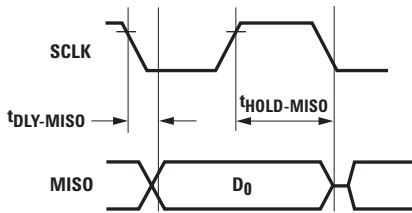


Figure 15. MISO delay

NOTE: The 500 ns minimum high state of SCLK is also the minimum MISO data hold time of the ADNS-5090. Since the falling edge of SCLK is actually the start of the next read or write command, the ADNS-5090 will hold the state of data on MISO until the falling edge of SCLK.

Required Timing between Read and Write Commands

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

Timing between Two Write Commands

If the rising edge of the SCLK for the last data bit of the second write command occurs before the required delay (t_{SWW}), then the first write command may not complete correctly.

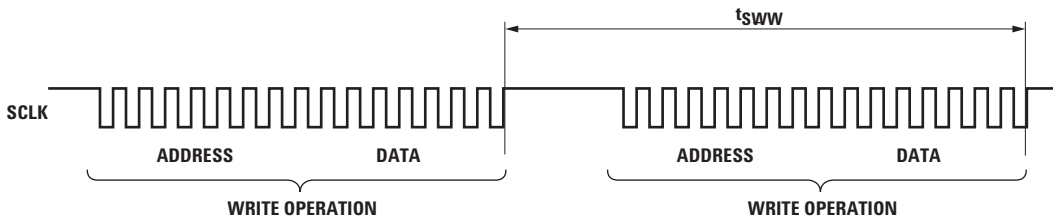


Figure 16. Timing between Two Write Commands

Timing between Write and Read Commands

If the rising edge of SCLK for the last address bit of the read command occurs before the required delay (t_{SWR}), the write command may not complete correctly.

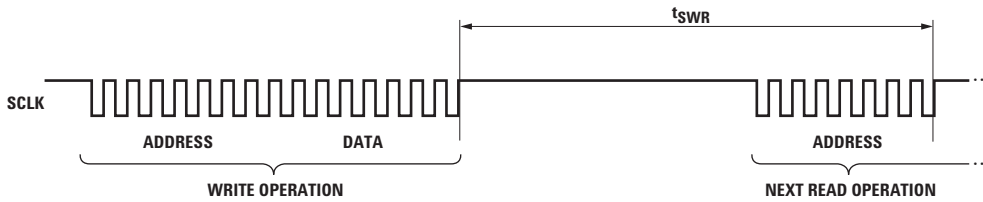


Figure 17. Timing between Write and Read Commands

Timing between Read and Subsequent Write or Read Commands

During a read operation SCLK should be delayed at least t_{SRAD} after the last address data bit to ensure that the ADNS-5090 has time to prepare the requested data. The falling edge of SCLK for the first address bit of either the read or write command must be at least t_{SRW} or t_{SRR} after the last SCLK rising edge of the last data bit of the previous read operation.

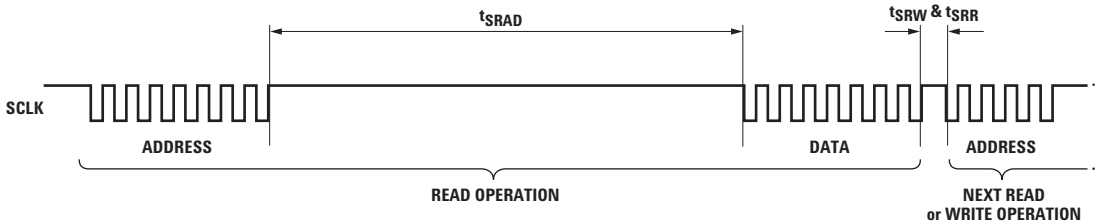


Figure 18. Timing between Read and Subsequent Write or Read Commands

Motion Burst Timing

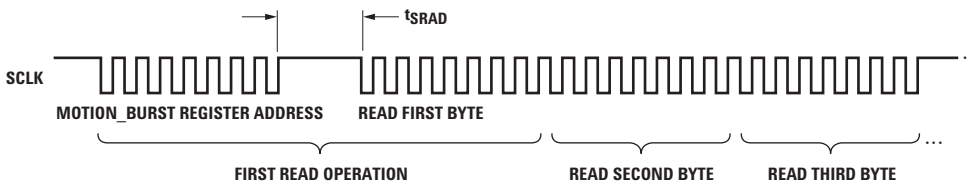


Figure 19. Motion Burst Timing

Burst Mode Operation

Burst mode is a special serial port operation mode that may be used to reduce the serial transaction time for a motion read. The speed improvement is achieved by continuous data clocking to or from multiple registers without the need to specify the register address, and by not requiring the normal delay period between data bytes.

Burst mode is initiated by reading the MOTION_BURST register (0x63). The ADNS-5090 will respond with the contents of the DELTA_X, DELTA_Y, SQUAL, SHUT_HI, SHUT_LO, and PIX_MAX and PIX_ACCUM registers in that order. The burst transaction can be terminated anywhere in the sequence after the DELTA_Y value by bringing the NCS pin high. The default “Read First Byte” is DELTA_X content and is specified in register 0x42 (BURST_READ_FIRST). The address that specifies the “Read First Byte” can be changed to address 0x00 – 0x02 (PROD_ID – MOTION_ST) or 0x05 – 0x08 (SQUAL – PIX_MAX) by writing to register 0x42.

After reading the MOTION_BURST address (0x63), the microcontroller must wait t_{SRAD} before starting to read the continuous data bytes. All data bits can be read with no delay between bytes by driving SCLK at the normal rate. The data are latched into the output buffer after the last address bit is received. After the burst transmission is complete, the micro-controller must raise the NCS line for at least t_{BEXIT} to terminate burst mode. The serial port is not available for use until it is reset with NCS, even for a second burst transmission.

Prior to reading MOTION_BURST register (0x63), MOTION_ST bit in MOTION_ST register (0x02) should be read. Alternatively, read MOTION_BURST register (0x63) only after MOTION pin is triggered.

Avago Technologies highly recommends the usage of burst mode operation in optical mouse sensor design applications.

Power Up Reset

Although ADNS-5090 does have an internal power up self reset circuitry, it is still highly recommended to follow the power up sequence below:

- i. Apply power
- ii. Drive NCS high, then low to reset the SPI port.
- iii. Write 0x5a to register 0x3a.

Reset

ADNS-5090 can be reset by writing 0x5a to register 0x3a. A full reset will thus be executed and any register settings must be reloaded. The table below shows the state of the various pins during reset.

State of Signal Pins after VDD is Valid

| Pin | During Reset | After Reset |
|--------|--------------|----------------|
| NCS | Ignored | Functional |
| MISO | Low | Depends on NCS |
| SCLK | Ignored | Depends on NCS |
| MOSI | Ignored | Depends on NCS |
| XY_LED | High | Functional |

Power Down

The ADNS-5090 can be set to Power Down mode by writing 0x02 to register 0x0d to disable the sensor. In addition, the SPI port should not be accessed during power down. Other ICs on the same SPI bus can be accessed, as long as the sensor’s NCS pin is not asserted. The table below shows the state of various pins during power down. To exit Power Down, write 0x5a to register 0x3a to reset the sensor in order to wake it up. A full reset will thus be executed. Wait t_{WAKEUP} before accessing the SPI port. Any register settings must then be reloaded.

| Pin | During Power Down |
|--------|-------------------|
| MOTION | Undefined |
| NCS | Functional* |
| MISO | Undefined |
| SCLK | Functional* |
| MOSI | Functional* |
| XY_LED | Low current |

Notes:

- * NCS pin must be held to 1 (HIGH) if SPI bus is shared with other devices. It can be in either state if the sensor is the only device in connected to the host micro-controller.
- * Reading of registers should only be performed after exiting from the power down mode. Any read operation during power down will not reflect the actual data of the registers.

Lift Detection Cutoff Algorithm

When the mouse is raised from the tracking surface which is also known as lifted condition, there is a specific z-height whereby the tracking of the sensor will cease. However the tracking cutoff height of the ADNS-5090 sensor varies with the different tracking surfaces. In general to have a lower tracking cutoff height than the default settings, below is the recommended algorithm illustrated in the form of a pseudo code.

```

If (MOTION)
{
    Delta_X = Read_Register(REG_DELTA_X);
    Delta_Y = Read_Register(REG_DELTA_Y);
    Squal = Read_Register(REG_SQUAL);
    Pixel_Accum = Read_Register(REG_PIX_ACCUM);

    If ( (Pixel_Accum < 105) && (Squal < 20) )
    {
        Delta_X = 0;
        Delta_Y = 0;
    }

    USB_Send_Report();
}

```

Registers

The ADNS-5090 registers are accessible via the serial port. The registers are used to read motion data and status as well as to set the device configuration.

| Address | Register Name | Register Description | Read/Write | Default Value |
|---------|------------------|---------------------------------|------------|---------------|
| 0x00 | PROD_ID | Product ID | R | 0x29 |
| 0x01 | REV_ID | Revision ID | R | 0x01 |
| 0x02 | MOTION_ST | Motion Status | R | 0x00 |
| 0x03 | DELTA_X | Delta_X | R | 0x00 |
| 0x04 | DELTA_Y | Delta_Y | R | 0x00 |
| 0x05 | SQUAL | Squal Quality | R | 0x00 |
| 0x06 | SHUT_HI | Shutter Open Time (Upper 8-bit) | R | 0x01 |
| 0x07 | SHUT_LO | Shutter Open Time (Lower 8-bit) | R | 0x00 |
| 0x08 | PIX_MAX | Maximum Pixel Value | R | 0x00 |
| 0x09 | PIX_ACCUM | Average Pixel Value | R | 0x00 |
| 0x0a | PIX_MIN | Minimum Pixel Value | R | 0x00 |
| 0x0b | PIX_GRAB | Pixel Grabber | R/W | 0x00 |
| 0x0d | MOUSE_CTRL | Mouse Control | R/W | 0x01 |
| 0x0e | RUN_DOWNSHIFT | Run to Rest1 Time | R/W | 0x46 |
| 0x0f | REST1_PERIOD | Rest1 Period | R/W | 0x00 |
| 0x10 | REST1_DOWNSHIFT | Rest1 to Rest2 Time | R/W | 0x4f |
| 0x11 | REST2_PERIOD | Rest2 Period | R/W | 0x09 |
| 0x12 | REST2_DOWNSHIFT | Rest2 to Rest3 Time | R/W | 0x2f |
| 0x13 | REST3_PERIOD | Rest3 Period | R/W | 0x31 |
| 0x21 | MOUSE_CTRL_EN | Mouse Control Enable Register | W | 0x00 |
| 0x35 | FRAME_IDLE | Frame Idle Setting | R/W | 0xf0 |
| 0x3a | RESET | Reset | W | 0x00 |
| 0x3f | NOT_REV_ID | Inverted Revision ID | R | 0xfe |
| 0x40 | LED_CTRL | LED Control | R/W | 0x00 |
| 0x41 | MOTION_CTRL | Motion Control | R/W | 0x40 |
| 0x42 | BURST_READ_FIRST | Burst Read Starting Register | R/W | 0x03 |
| 0x43 | AUTO_LED_CTRL | AUTO LED Control | R/W | 0x08 |
| 0x45 | REST_MODE_CONFIG | Rest Mode Configuration | R/W | 0x00 |
| 0x63 | MOTION_BURST | Burst Read | R | 0x00 |

PROD_ID Address: 0x00

Product ID Register

Access: Read Reset Value: 0x29

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | PID7 | PID6 | PID5 | PID4 | PID3 | PID2 | PID1 | PID0 |

Data Type: 8-Bit unsigned integer

USAGE: This register contains a unique identification assigned to the ADNS-5090. The value in this register does not change; it can be used to verify that the serial communications link is functional. If using this register to verify serial communications link during rest modes, please read following registers in this sequence: 0x00, 0x02, 0x03, 0x04, 0x00 (regardless of register 0x02's status). If both or either one of the read 0x00 value is correct, no additional action is required as the serial communication link is good. Only if both read 0x00 value attempts are wrong, perform a reset operation to the sensor to restore the serial communications link.

Note: Highly recommended to use Motion pin function during rest modes for motion detection.

REV_ID Address: 0x01

Revision ID Register

Access: Read Reset Value: 0x01

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RID7 | RID6 | RID5 | RID4 | RID3 | RID2 | RID1 | RID0 |

Data Type: 8-Bit unsigned integer

USAGE: This register contains the IC revision. It is subject to change when new IC versions are released.

MOTION_ST Address: 0x02

Motion Status Register

Access: Read/Write Reset Value: 0x00

| | | | | | | | | |
|-------|-----------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MOTION_ST | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD |

Data Type: Bit field.

USAGE: Register 0x02 allows the user to determine if motion has occurred since the last time it was read. If the MOTION_ST bit is set, then the user should read registers 0x03 (DELTA_X) and 0x04 (DELTA_Y) to get the accumulated motion data. Read this register before reading the DELTA_X and DELTA_Y registers. Writing any data into this register clears MOTION_ST bit, DELTA_X and DELTA_Y registers. However the written data byte will not be saved.

| Bit | Field Name | Description |
|-----|------------|--|
| 7 | MOTION_ST | Motion detected since last report 0 = No motion (default) 1 = Motion occurred, data in DELTA_X and DELTA_Y registers ready to be read |
| 6-0 | RSVD | Reserved |

DELTA_X

Address: 0x03

X Displacement Register

Access: Read

Reset Value: 0x00

| | | | | | | | | |
|-------|----|----|----|----|----|----|----|----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | X7 | X6 | X5 | X4 | X3 | X2 | X1 | X0 |

Data Type: Eight bit 2's complement number.

USAGE: X-axis movement in counts since last report. Absolute value is determined by resolution. Reading this register clears the content of this register.



NOTE: Registers 0x03 and 0x04 MUST be read consecutively.

DELTA_Y

Address: 0x04

Y Displacement Register

Access: Read

Reset Value: 0x00

| | | | | | | | | |
|-------|----|----|----|----|----|----|----|----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | Y7 | Y6 | Y5 | Y4 | Y3 | Y2 | Y1 | Y0 |

Data Type: Eight bit 2's complement number.

USAGE: Y-axis movement in counts since last report. Absolute value is determined by resolution. Reading this register clears the content of this register.



NOTE: Avago RECOMMENDS that registers 0x03 and 0x04 be read consecutively.

SQUAL

Address: 0x05

Squal Quality Register

Access: Read

Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | SQ7 | SQ6 | SQ5 | SQ4 | SQ3 | SQ2 | SQ1 | SQ0 |

Data Type:

Upper 8 bits of a 9-bit unsigned integer.

USAGE:

SQUAL (Surface Quality) is a measure of the number of valid features visible by the sensor in the current frame.

The maximum SQUAL register value is 128. Since small changes in the current frame can result in changes in SQUAL, variations in SQUAL when looking at a surface are expected. The graph below shows 800 sequentially acquired SQUAL values, while a sensor was moved slowly over white paper. SQUAL is nearly equal to zero, if there is no surface below the sensor. SQUAL is typically maximized when the navigation surface is at the optimum distance from the imaging lens (the nominal Z-height).

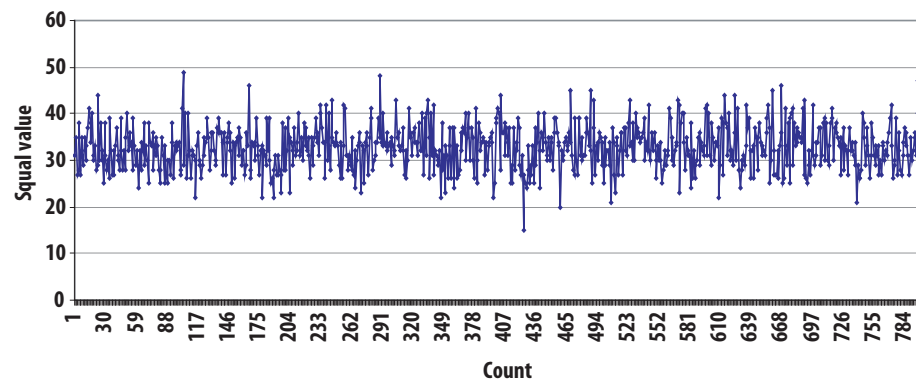


Figure 20. Squal values (white paper)

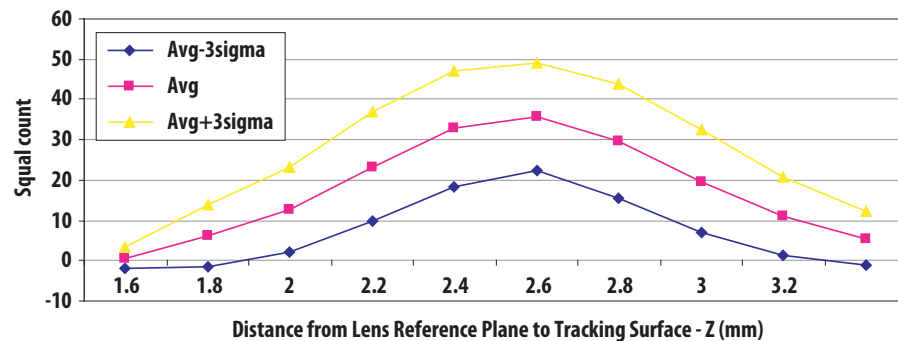


Figure 21. Mean squal vs. Z (White Paper)

SHUT_HI Address: 0x06
 Shutter Open Time (Upper 8-bits) Register
 Access: Read Reset Value: 0x01

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|----|----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | S15 | S14 | S13 | S12 | S11 | S10 | S9 | S8 |

SHUT_LO Address: 0x07
 Shutter Open Time (Lower 8-bits) Register
 Access: Read Reset Value: 0x00

| | | | | | | | | |
|-------|----|----|----|----|----|----|----|----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | S7 | S6 | S5 | S4 | S3 | S2 | S1 | S0 |

Data Type: Sixteen bit unsigned integer.

USAGE: Units are in clock cycles. Read SHUT_HI first, then SHUT_LO. They should be read consecutively. The shutter is adjusted to keep the average and maximum pixel values within normal operating ranges. The shutter value is automatically adjusted.

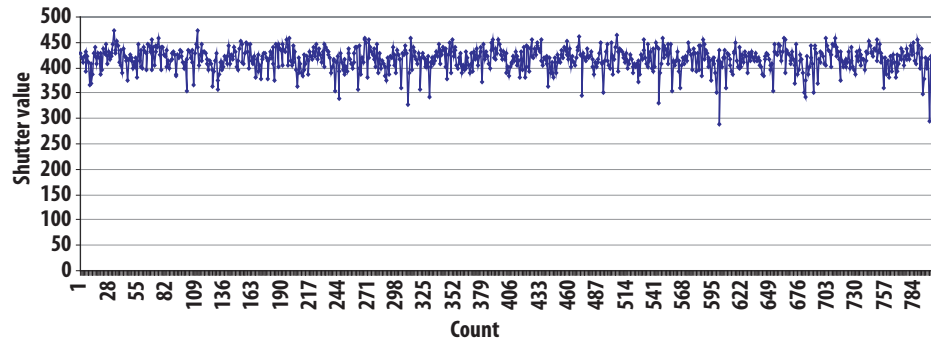


Figure 22. Shutter (white paper).

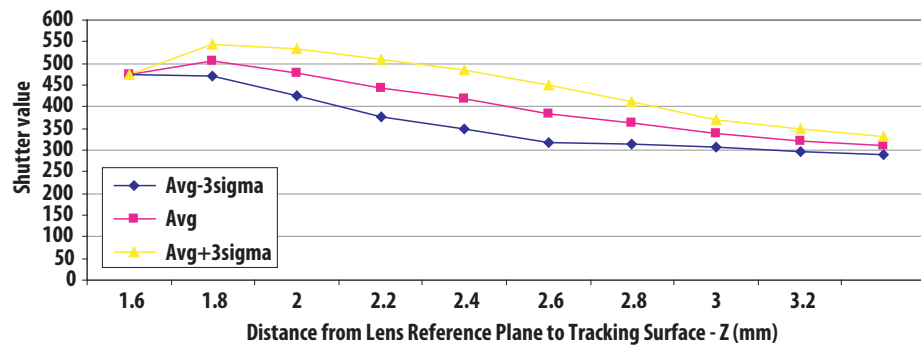


Figure 23. Mean shutter vs. Z (white paper).

PIX_MAX Address: 0x08

Maximum Pixel Value Register

Access: Read Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MP7 | MP6 | MP5 | MP4 | MP3 | MP2 | MP1 | MP0 |

Data Type: Eight-bit number.

USAGE: Store the highest pixel value in current frame. Minimum value = 0, maximum value = 255. The highest pixel value may vary with different frame.

PIX_ACCUM Address: 0x09

Average Pixel Value Register

Access: Read Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | AP7 | AP6 | AP5 | AP4 | AP3 | AP2 | AP1 | AP0 |

Data Type: High 8-bits of an unsigned 16-bit integer.

USAGE: This register stores the accumulated pixel value of the last image taken. This register can be used to find the average pixel value, where Average Pixel = (register value AP[7:0]) * 0.71
The maximum accumulated value is 45847 but only bits [15:8] are reported, therefore the maximum register value is 179. The minimum is 0. The PIX_ACCUM value may vary with different frame.

PIX_MIN Address: 0x0a

Minimum Pixel Value Register

Access: Read Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MP7 | MP6 | MP5 | MP4 | MP3 | MP2 | MP1 | MP0 |

Data Type: Eight-bit number.

USAGE: Store the lowest pixel value in current frame. Minimum value = 0, maximum value = 127. The minimum pixel value may vary with different frame.

PIX_GRAB

Address: 0x0b

Pixel Grabber Register

Access: Read/Write

Reset Value: 0x00

| | | | | | | | | |
|-------|----------|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | PG_VALID | PG6 | PG5 | PG4 | PG3 | PG2 | PG1 | PG0 |

Data Type: Eight bit word.

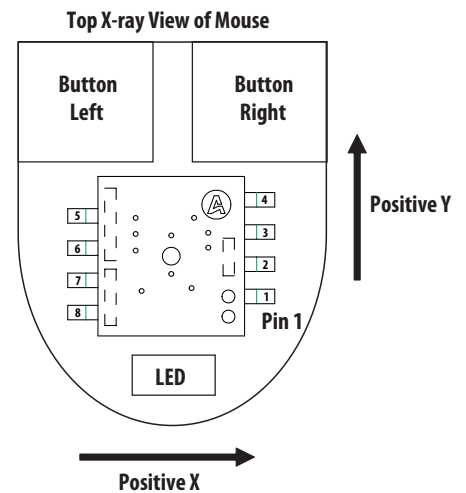
USAGE: The pixel grabber captures 1 pixel per frame. Bit-7 (MSB) of this register will be set to indicate that the 7-bit pixel data (PG[6:0]) is valid for grabbing. In a 19x19 pixel array, it will take 361 read operations to grab all the pixels to form the complete image.

| Bit(s) | Field Name | Description |
|--------|------------|---------------------|
| 7 | PG_VALID | Pixel Grabber Valid |
| 6:0 | PG[6:0] | Pixel Data |

NOTE: Any write operation into this register will reset the grabber to origin (pixel 0 position). The sensor should not be moved before the 361 read operations are completed to ensure original data is grabbed to produce good (uncorrupted) image.

19x19 Pixel Array Address Map – (View from top of sensor)

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|-------|--|
| 342 | 323 | 304 | 285 | 266 | 247 | 228 | 209 | 190 | 171 | 152 | 133 | 114 | 95 | 76 | 57 | 38 | 19 | 0 | First | |
| 343 | 324 | 305 | 286 | 267 | 248 | 229 | 210 | 191 | 172 | 153 | 134 | 115 | 96 | 77 | 58 | 39 | 20 | 1 | | |
| 344 | 325 | 306 | 287 | 268 | 249 | 230 | 211 | 192 | 173 | 154 | 135 | 116 | 97 | 78 | 59 | 40 | 21 | 2 | | |
| 345 | 326 | 307 | 288 | 269 | 250 | 231 | 212 | 193 | 174 | 155 | 136 | 117 | 98 | 79 | 60 | 41 | 22 | 3 | | |
| 346 | 327 | 308 | 289 | 270 | 251 | 232 | 213 | 194 | 175 | 156 | 137 | 118 | 99 | 80 | 61 | 42 | 23 | 4 | | |
| 347 | 328 | 309 | 290 | 271 | 252 | 233 | 214 | 195 | 176 | 157 | 138 | 119 | 100 | 81 | 62 | 43 | 24 | 5 | | |
| 348 | 329 | 310 | 291 | 272 | 253 | 234 | 215 | 196 | 177 | 158 | 139 | 120 | 101 | 82 | 63 | 44 | 25 | 6 | | |
| 349 | 330 | 311 | 292 | 273 | 254 | 235 | 216 | 197 | 178 | 159 | 140 | 121 | 102 | 83 | 64 | 45 | 26 | 7 | | |
| 350 | 331 | 312 | 293 | 274 | 255 | 236 | 217 | 198 | 179 | 160 | 141 | 122 | 103 | 84 | 65 | 46 | 27 | 8 | | |
| 351 | 332 | 313 | 294 | 275 | 256 | 237 | 218 | 199 | 180 | 161 | 142 | 123 | 104 | 85 | 66 | 47 | 28 | 9 | | |
| 352 | 333 | 314 | 295 | 276 | 257 | 238 | 219 | 200 | 181 | 162 | 143 | 124 | 105 | 86 | 67 | 48 | 29 | 10 | | |
| 353 | 334 | 315 | 296 | 277 | 258 | 239 | 220 | 201 | 182 | 163 | 144 | 125 | 106 | 87 | 68 | 49 | 30 | 11 | | |
| 354 | 335 | 316 | 297 | 278 | 259 | 240 | 221 | 202 | 183 | 164 | 145 | 126 | 107 | 88 | 69 | 50 | 31 | 12 | | |
| 355 | 336 | 317 | 298 | 279 | 260 | 241 | 222 | 203 | 184 | 165 | 146 | 127 | 108 | 89 | 70 | 51 | 32 | 13 | | |
| 356 | 337 | 318 | 299 | 280 | 261 | 242 | 223 | 204 | 185 | 166 | 147 | 128 | 109 | 90 | 71 | 52 | 33 | 14 | | |
| 357 | 338 | 319 | 300 | 281 | 262 | 243 | 224 | 205 | 186 | 167 | 148 | 129 | 110 | 91 | 72 | 53 | 34 | 15 | | |
| 358 | 339 | 320 | 301 | 282 | 263 | 244 | 225 | 206 | 187 | 168 | 149 | 130 | 111 | 92 | 73 | 54 | 35 | 16 | | |
| 359 | 340 | 321 | 302 | 283 | 264 | 245 | 226 | 207 | 188 | 169 | 150 | 131 | 112 | 93 | 74 | 55 | 36 | 17 | | |
| Last | 360 | 341 | 322 | 303 | 284 | 265 | 246 | 227 | 208 | 189 | 170 | 151 | 132 | 113 | 94 | 75 | 56 | 37 | 18 | |



MOUSE_CTRL Address: 0x0d

Mouse Control Register

Access: Read/Write Reset Value: 0x01

| | | | | | | | | |
|-------|------|------|--------|------|------|------|----|-------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RSVD | RSVD | RES_EN | RES2 | RES1 | RES0 | PD | RES_D |

Data Type: Bit field

USAGE: Resolution and chip reset information can be accessed or to be edited by this register.

| Bit(s) | Field Name | Description |
|--------|------------|---|
| 7:6 | RSVD | Reserved |
| 5 | RES_EN | Enable resolution settings set on MOUSE_CTRL [4:2] |
| 4:2 | RES [2:0] | Resolution 000: 1000 dpi (default) 001: 250 dpi 010: 500 dpi 011: 1250 dpi 100: 1500 dpi 101: 1750 dpi |
| 1 | PD | Power Down |
| 0 | RES_D | 0: 500 dpi 1: 1000 dpi (default) |

NOTE:

1. Setting MOUSE_CTRL [5] bit to '1' will supersede and ignore MOUSE_CTRL [0] setting.
2. Each read/write operation of this register should be followed by a write operation: write register 0x21 with 0x10.

RUN_DOWNSHIFT Address: 0x0e

Run to Rest1 Time Register

Access: Read/Write Reset Value: 0x46

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RUD7 | RUD6 | RUD5 | RUD4 | RUD3 | RUD2 | RUD1 | RUD0 |

Data Type: Eight bit number

USAGE: This register sets the Run to Rest1 mode downshift time. The time is the value of this register multiply by 16 frames. Min value for this register must be 1.

For example at typical frame rate of 2250fps, each frame period is about 444us. Therefore the run downshift time would be Register value (0x46) * 16 * frame period = 70 * 16 * 444us = 497.3ms

REST1_PERIOD Address: 0x0f

Rest1 Period Register

Access: Read/Write Reset Value: 0x00

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | R1P7 | R1P6 | R1P5 | R1P4 | R1P3 | R1P2 | R1P1 | R1P0 |

Data Type: Eight bit number

USAGE: This register sets the Rest1 period. $\text{Period} = (\text{register value R1P [7:0]} + 1) \times 7\text{ms}$ (typical slow clock period). Min value for this register is 0. Max value is 0xFD.

NOTE: Writing into this register when the sensor itself is operating in this rest mode may result in unexpected behavior of the sensor. To avoid this from happening, below commands should be incorporated prior and after the write command into this register.

w 22 80 -> write 0x80H into register 0x22H prior to writing into this register

w 0f XX -> writing into this register

w 22 00 -> write 0x00H into register 0x22H after writing into this register

REST1_DOWNSHIFT Address: 0x10

Rest1 to Rest2 Downshift Time Register

Access: Read/Write Reset Value: 0x4f

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | R1D7 | R1D6 | R1D5 | R1D4 | R1D3 | R1D2 | R1D1 | R1D0 |

Data Type: Eight bit number

USAGE: This register sets the Rest1 to Rest2 mode downshift time. $\text{Time} = (\text{register value R1D [7:0]} \times (\text{Rest1 period}) \times 16$. Min value for this register is 0.

REST2_PERIOD Address: 0x11

Rest2 Period Register

Access: Read/Write Reset Value: 0x09

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | R2P7 | R2P6 | R2P5 | R2P4 | R2P3 | R2P2 | R2P1 | R2P0 |

Data Type: Eight bit number

USAGE: This register sets the Rest2 period. $\text{Period} = (\text{register value R2P [7:0]} + 1) \times 7\text{ms}$ (typical slow clock period). Min value for this register is 0. Max value is 0xFD.

NOTE: Writing into this register when the sensor itself is operating in this rest mode may result in unexpected behavior of the sensor. To avoid this from happening, below commands should be incorporated prior and after the write command into this register.

w 22 80 -> write 0x80H into register 0x22H prior to writing into this register

w 11 XX -> writing into this register

w 22 00 -> write 0x00H into register 0x22H after writing into this register

REST2_DOWNSHIFT Address: 0x12

Rest2 to Rest3 Downshift Time Register

Access: Read/Write Reset Value: 0x2f

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | R2D7 | R2D6 | R2D5 | R2D4 | R2D3 | R2D2 | R2D1 | R2D0 |

Data Type: Eight bit number

USAGE: This register sets the Rest1 to Rest2 mode downshift time. Time = (register value R2D [7:0]) x (Rest2 period) x 128. Min value for this register is 0.

REST3_PERIOD Address: 0x13

Rest3 Period Register

Access: Read/Write Reset Value: 0x31

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | R3P7 | R3P6 | R3P5 | R3P4 | R3P3 | R3P2 | R3P1 | R3P0 |

Data Type: Eight bit number

USAGE: This register sets the Rest3 period. Period = (register value R3P [7:0] +1) x 7ms (typical slow clock period). Min value for this register is 0. Max value is 0xFD.

NOTE: Writing into this register when the sensor itself is operating in this rest mode may result in unexpected behavior of the sensor. To avoid this from happening, below commands should be incorporated prior and after the write command into this register.

w 22 80 -> write 0x80H into register 0x22H prior to writing into this register

w 13 XX -> writing into this register

w 22 00 -> write 0x00H into register 0x22H after writing into this register

MOUSE_CTRL_EN Address: 0x21

Mouse Control Enable Register

Access: Write Reset Value: 0x00

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MCE7 | MCE6 | MCE5 | MCE4 | MCE3 | MCE2 | MCE1 | MCE0 |

Data Type: Eight bit unsigned integer.

USAGE: Write 0x10 to this register after accessing register 0x0d to complete read/write operations.

FRAME_IDLE Address: 0x35

Frame Idle Setting Register

Access: Read/Write Reset Value: 0xf0

| | | | | | | | | |
|-------|---|---|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | 1 | 1 | FR5 | FR4 | FR3 | FR2 | FR1 | FR0 |

Data Type: Eight bit unsigned integer.

USAGE: This register is used to control the frame rate. The value in this register is used to add frame idling time, which effectively reduces the frame rate..

$$\text{frame_idle_time (in clock counts)} = (\text{register value}) * 32$$
$$\text{Frame period (in clock counts)} = \text{shutter_time (reg 0x06 and reg 0x07)} + (3400 \text{ clocks}) + \text{frame_idle_time}$$

When this register is set to 0xf0, the typical frame rate is about 2250 fps @26MHz

RESET Address: 0x3a

Reset Register

Access: Write Reset Value: 0x00

| | | | | | | | | |
|-------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RST7 | RST6 | RST5 | RST4 | RST3 | RST2 | RST1 | RST0 |

Data Type: Eight bit unsigned integer.

USAGE: This register is used as chip reset by writing 0x5a into this register.

NOT_REV_ID Address: 0x3f

Inverted Revision ID Register

Access: Read Reset Value: 0xfe

| | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RRID7 | RRID6 | RRID5 | RRID4 | RRID3 | RRID2 | RRID1 | RRID0 |

Data Type: Eight bit unsigned integer

USAGE: This register contains the inverse of the revision ID which is located at register 0x01.

LED_CTRL Address: 0x40

LED Control Register

Access: Read/Write Reset Value: 0x00

| | | | | | | | | |
|-------|------|------|------|------|------|------|-------|-------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RSVD | RSVD | RSVD | RSVD | LCOF | RSVD | LSEL1 | LSEL0 |

Data Type: Eight bit unsigned integer

USAGE: This register is used to control the LED operating mode and current to optimize/minimize the power consumption.

| Bit | Field Name | Description |
|-----|------------|---|
| 7:4 | RSVD | Reserved |
| 3 | LCOF | 0 : Normal operation (default) 1 : LED Continuous Off |
| 2 | RSVD | Reserved |
| 1:0 | LSEL[1:0] | 0x0: LED Current set to 20mA (default) 0x1: LED Current set to 15mA 0x2: LED Current set to 36mA 0x3: LED Current set to 30mA |

NOTE: If LED is operating in AUTO current switching mode (AUTO_LED_CONTROL [0] at address 0x43 is cleared, LED current setting (LED_CONTROL [1:0]) will be ignored. Only when AUTO current switching is disabled through setting AUTO_LED_CONTROL [0], the LED drive current is determined by LED_CONTROL [1:0]

MOTION_CTRL Address: 0x41

Motion Control Register

Access: Read/Write Reset Value: 0x40

| | | | | | | | | |
|-------|-------|-------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MOT_A | MOT_S | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD |

Data Type: Eight bit unsigned integer

USAGE: This register is used to set the feature of MOTION interrupt output. If MOT_S bit is clear, the MOTION pin is level-sensitive. With active low (MOT_A bit is clear) level-sensitive configuration, the MOTION pin will be driven low when there is motion detected indicating there is motion data in DELTA_X and DELTA_Y registers. The mouse microcontroller can read MOTION_ST register, DELTA_X register, and then DELTA_Y register sequentially. After all the motion data has been read, DELTA_X and DELTA_Y registers will be zero, the MOTION pin will be driven high by the sensor.

If MOT_S is set, the MOTION pin is edge sensitive. If MOT_A is also set, it means active high or rising edge triggered. Whenever there is motion detected by the sensor, a pulse (~230us) will be sent out through this pin. This pulse can be used to trigger or wake the controller up from its sleep mode to read motion data from the sensor. The controller can then read MOTION_ST register, DELTA_X register, and then DELTA_Y register sequentially. (Refer to Motion Function for more information)

| Bit | Field Name | Description |
|-----|------------|--|
| 7 | MOT_A | MOTION Active 0 : LOW (default) 1 : HIGH |
| 6 | MOT_S | MOTION Sensitivity 0 : Level sensitive 1 : Edge sensitive (default) |
| 5:0 | RSVD | Reserved |

BURST_READ_FIRST Address: 0x42

Burst Read Starting Address Register

Access: Read/Write Reset Value: 0x03

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | BM7 | BM6 | BM5 | BM4 | BM3 | BM2 | BM1 | BM0 |

Data Type: Eight bit unsigned integer

USAGE: This register provides the starting register address the sensor will read during Burst Mode. For more information, refer to Burst Mode Operation.

Note: To change the burst mode starting address from default (DELTA_X or 0x03) pull the NCS low, set the BURST_READ_FIRST register with the burst mode starting address, read register 0x63 for burst reads, and terminate the burst reads by pulling NCS high. This must be repeated each time when performing burst reads with address other than default.

AUTO_LED_CTRL Address: 0x43

AUTO LED Control

Access: Read/Write Reset Value: 0x08

| | | | | | | | | |
|-------|------|------|------|------|------------|------------|--------|-----------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RSVD | RSVD | RSVD | RSVD | LED_HI [1] | LED_HI [0] | LED_LO | A_LED_DIS |

Data Type: Eight bit unsigned integer

USAGE: This register enables AUTO LED current switching. This is a 'smart' LED feature whereby the LED current is self adjusting between the low and high current settings (bit 3:1) according to the brightness of the tracking surface if this feature is enabled (via clearing bit 0). The brighter the surface, the lower the LED current will be. If A_LED_DIS (bit 0) is set, this means AUTO LED mode is disabled, then the LED current is determined by LSEL[1:0] setting in LED_CTRL register (0x40).

| Bit | Field Name | Description |
|-----|--------------|--|
| 7:4 | RSVD | Reserved |
| 3:2 | LED_HI [1:0] | AUTO LED High Current 0x0: Auto LED high current is 15mA 0x1: Auto LED high current is 20mA 0x2: Auto LED high current is 30mA (default) 0x3: Auto LED high current is 36mA |
| 1 | LED_LO | AUTO LED Low Current 0: Auto LED low current is 15mA (default) 1: Auto LED low current is 20mA |
| 0 | A_LED_DIS | AUTO LED Disable 0: AUTO LED enabled (default) 1: AUTO LED disabled |

Note: When AUTO LED is enabled, the AUTO LED current will be switched between low and high current setting determined by LED_LO and LED_HI [1:0]. If LED_LO current setting is higher than the LED_HI, the current will be based on the higher setting. For example if LED_LO is 20mA and LED_HI is 15mA, the AUTO LED current will be fixed at 20mA.

REST_MODE_CONFIG Address: 0x45

Rest Mode Configuration Register

Access: Read/Write Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | RM1 | RM0 | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD |

Data Type: Eight bit unsigned integer

USAGE: This register is used to set the operating mode of the ADNS-5090.

| Bit | Field Name | Description |
|-----|------------|--|
| 7:6 | RM[1:0] | Sensor Operating Mode 0x00: Normal (default) 0x01: Rest 1 0x02: Rest 2 0x03: Rest 3 |
| 5:0 | RSVD | Reserved |

Read operation to REST_MODE_CONFIG indicates which mode the sensor is in. Write operation into this register will force the sensor into rest modes (Rest 1, 2 or 3). Write the value 0x40 into 0x45 register to force sensor into Rest 1, 0x80 to Rest 2 or 0xC0 to Rest 3. To get out of any forced rest mode, write 0x00 into this register to set back to normal mode.

Note: Write 0x00 to register 0x22 during start up sensor initialization to enable configuration to this register.

MOTION_BURST Address: 0x63

Burst Read Register

Access: Read Reset Value: 0x00

| | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | MB7 | MB6 | MB5 | MB4 | MB3 | MB2 | MB1 | MB0 |

Data Type: Various.

USAGE: This register is used to enable burst mode. Burst is initiated by a read of this register, which will then return continuous data starting from the address stored in BURST_READ FIRST register through register 0x09. If burst operation is not terminated at this point, the internal address counter stops incrementing and register 0x09 value will be returned repeatedly. Burst operation is terminated when NCS is asserted high. For more information, refer to Burst Mode Operation.

For product information and a complete list of distributors, please go to our web site: www.avagotech.com