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## SDNS-3988

### High Performance Gaming Sensor

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#### Description

SDNS-3988 high performance gaming sensor is a new addition to PixArt Imaging's gaming sensor family. The tracking system comprises of navigation IC, HSDL-4261 IR LED and lens. It provides enhanced features such as user calibrated lift detection, variable frame rate, programmable resolution, angle tunability, angle snap plus configurable sleep and wake up time to suit various gamers' preferences.

This gaming sensor is in a 58-pin QFN package. It is designed to be used with ADNS-2120-001 trim lens to achieve optimum performance featured in this document.

#### Theory of Operation

The sensor measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the direction and magnitude of movement. It 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  $\Delta x$  and  $\Delta y$  relative displacement values. An external microcontroller reads the  $\Delta x$  and  $\Delta y$  information from the sensor serial port. The microcontroller then translates the data into PS2, USB, or RF signals before sending them to the host PC or game console.

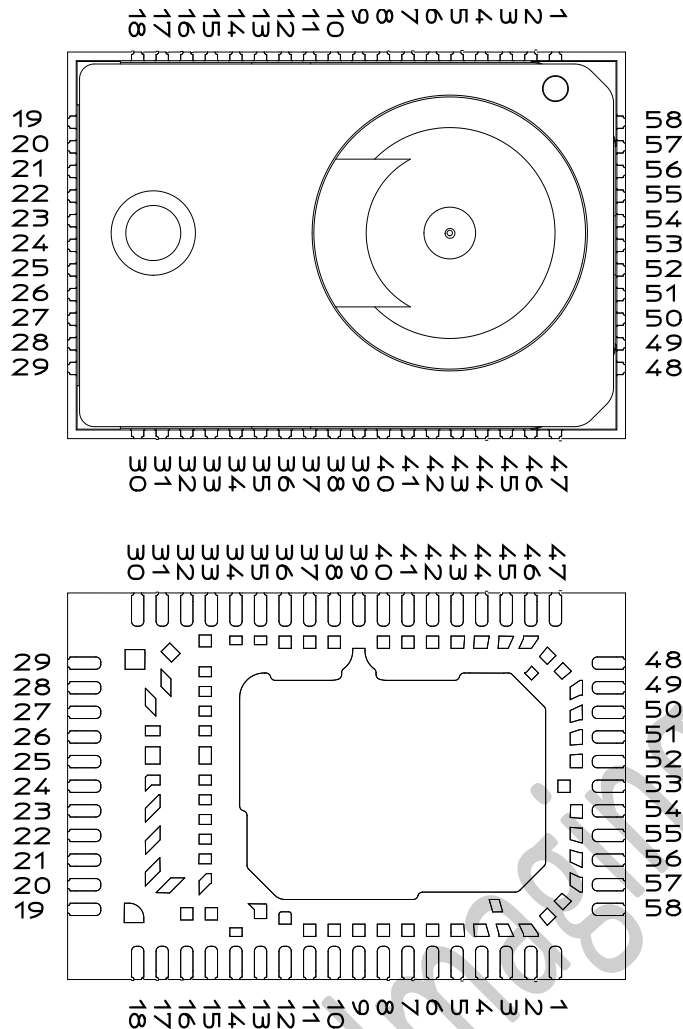
#### Features

- Small form factor QFN package
- VDDIO range: 1.65 – 3.3V
- 16-bits motion data registers
- Maximum speed motion detection of 200ips and acceleration up to 50g
- Variable Frame Rate for optimum power performance
- Motion detect pin output
- Internal oscillator – no external clock input needed
- Enhanced Programmability
  - Frame rate up to 12500fps
  - Lift Detection
    - Default lift cut-off height – typical 3mm from tracking surface
    - Manually calibrated lift cut-off height – optimized for individual surface
  - Resolution up to 6400cpi with step of ~50cpi
  - X and Y axis independent resolution setting
  - Register enabled Rest Modes
  - Angle Snap and Angle Tunability

#### Applications

- Corded and cordless gaming mice
- Motion input devices

## Device Pinout



| Pin No  | Pin Name    | Input / Output / Power | Description                              |
|---------|-------------|------------------------|------------------------------------------|
| 1 – 3   | NC          | -                      |                                          |
| 4       | PWR_OPT2    | IN                     | Refer Table 1                            |
| 5       | PWR_OPT1    | IN                     | Refer Table 1                            |
| 6       | XYLED       | IN                     | LED Illumination Control Input           |
| 7       | VDDIO       | PWR                    | IO Voltage                               |
| 8       | MOTION      | OUT                    | Motion Detect (Active Low Output)        |
| 9       | MOSI        | IN                     | Serial Data Input (Master Out/Slave In)  |
| 10      | SCLK        | IN                     | Serial Clock Input                       |
| 11      | MISO        | OUT                    | Serial Data Output (Master In/Slave Out) |
| 12      | GND         | PWR                    | Ground                                   |
| 13      | NCS         | IN                     | Chip Select (Active Low Input)           |
| 14 – 33 | NC          | -                      | -                                        |
| 34, 45  | VDD3/REFB   | PWR                    | Refer Table 1                            |
| 35 – 38 | NC          | -                      | -                                        |
| 39      | GND         | PWR                    | Ground                                   |
| 40      | DGND        | PWR                    | Ground (digital)                         |
| 41 – 42 | REFA/VDD1_8 | PWR                    | Refer Table 1                            |
| 43 – 44 | NC          | -                      | -                                        |
| 46      | VDD5/VDD3   | PWR                    | Refer Table 1                            |
| 47 – 52 | NC          | -                      | -                                        |
| 53      | GND         | PWR                    | Ground                                   |
| 54 – 58 | NC          | -                      | -                                        |

Figure 1. Device Pinout of SDNS-3988

Table 1: Power Option Selections

|                 | Low (connect with GND, 0V)                                                                                                                | High (connect with VDD supply, 3V)                                                                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>PWR_OPT1</b> | Enable internal 5V-to-3V regulator (VDD5 input pin 46 need to be connected to 5V with REFB pin 34 and 45 connected to *bypass capacitors) | Disable internal 5V-to-3V regulator (VDD3 input pin 34, 45 and 46 need to be connected to 3V supply)   |
| <b>PWR_OPT2</b> | Enable internal 3V-to-1.8V regulator (REFA pin 41 and 42 need to be connected to *bypass capacitors)                                      | Disable internal 3V-to-1.8V regulator (VDD1_8 input pin 41 and 42 need to be connected to 1.8V supply) |

\* Refer to schematic for bypass capacitors value.

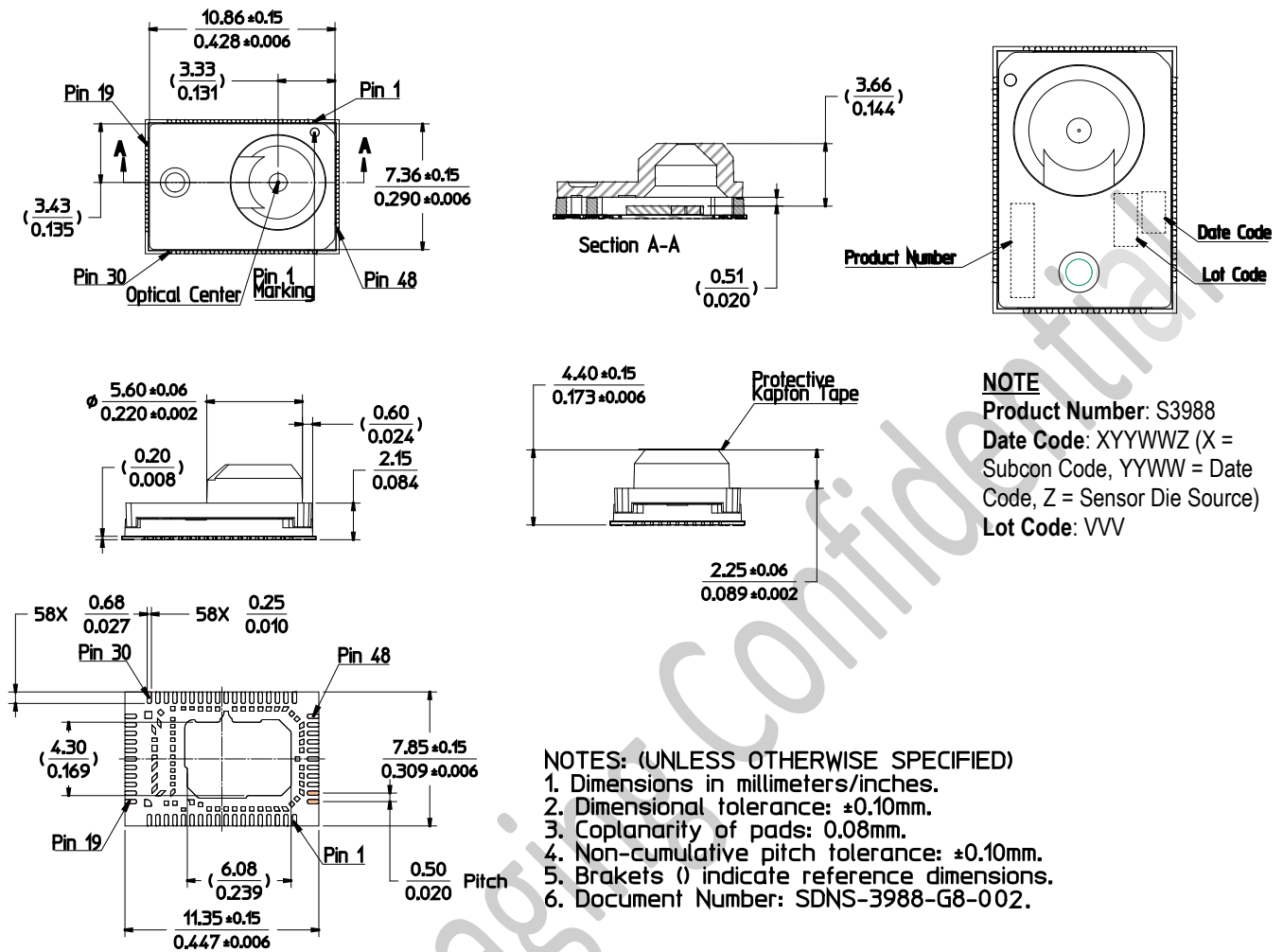
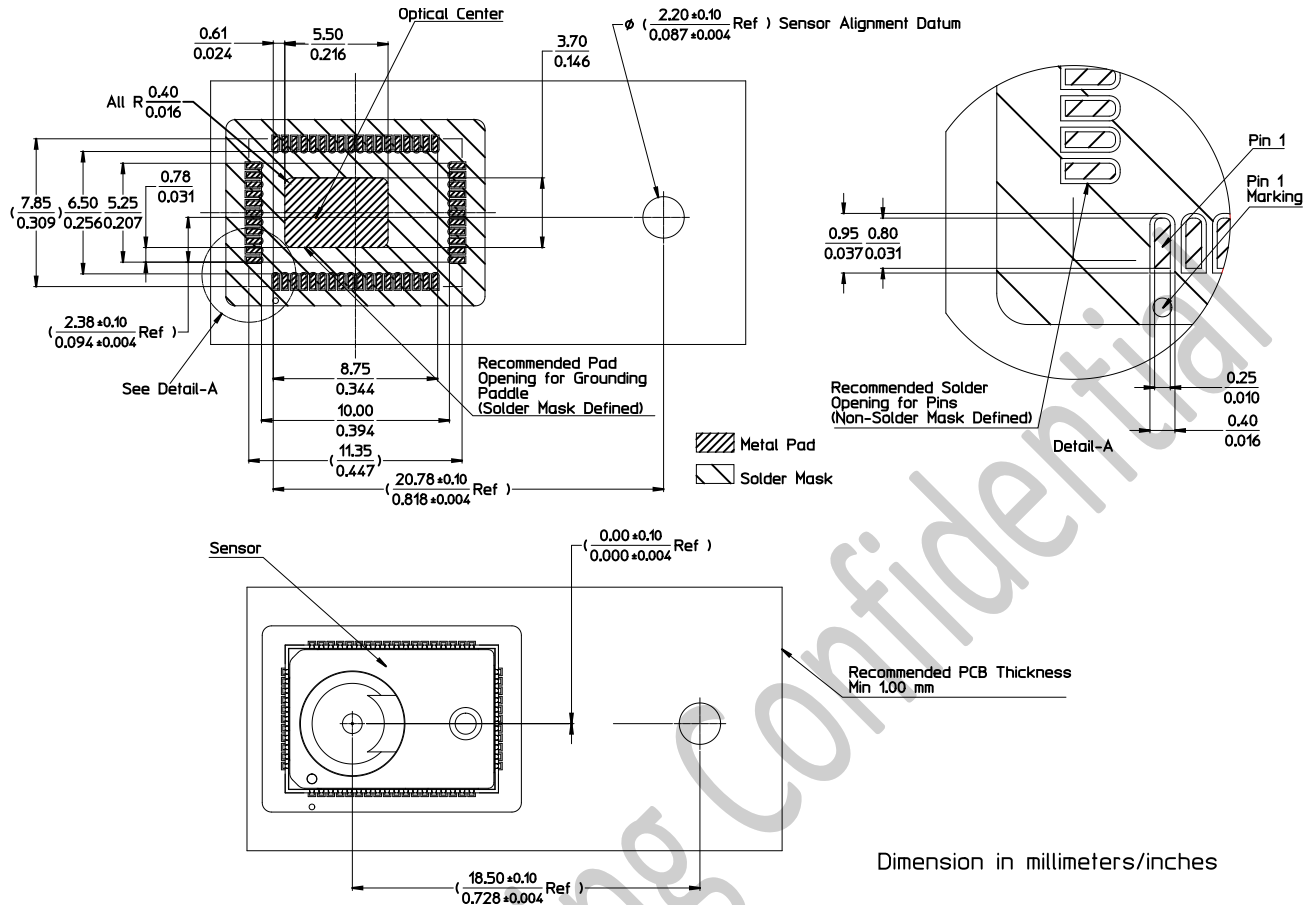
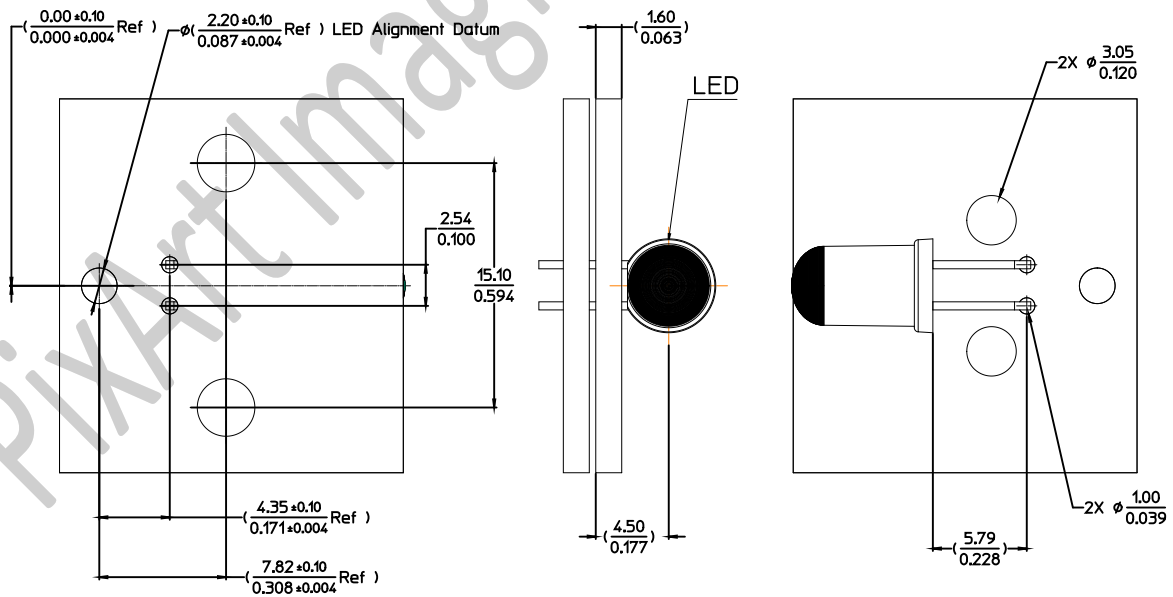


Figure 2. Package Outline Drawing

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



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



**Figure 4. Recommended PCB Mechanical Cutouts and Spacing (Top View) for IR LED**

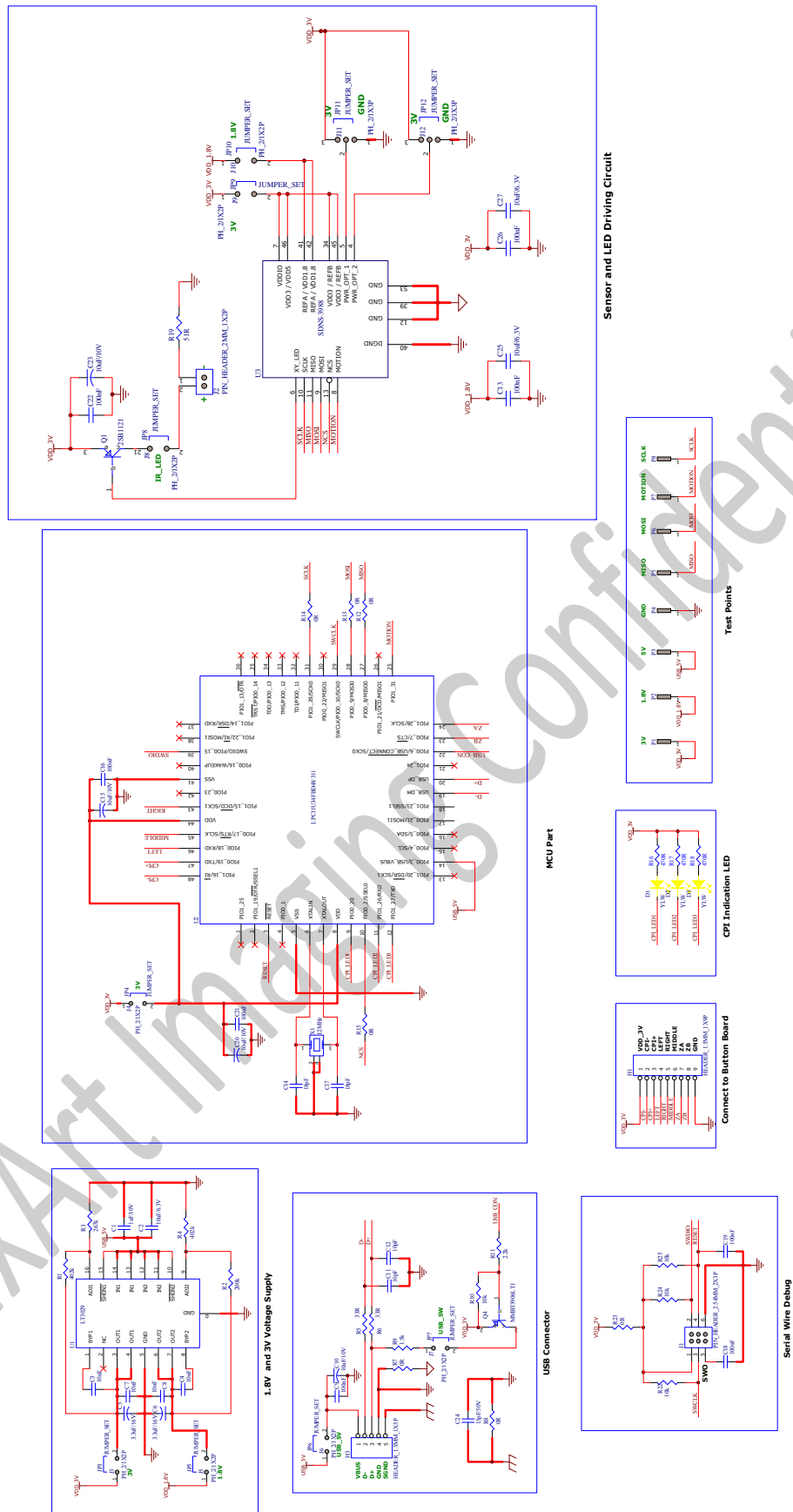


Figure 13. Schematic Diagram for 5-Button Scroll Wheel Corded Mouse (PCB Board 1)



### Absolute Maximum Ratings

| Parameter              | Symbol             | Minimum | Maximum | Units | Notes                                                     |
|------------------------|--------------------|---------|---------|-------|-----------------------------------------------------------|
| Storage Temperature    | T <sub>S</sub>     | -40     | 85      | °C    | MSL level1                                                |
| Lead-Free Solder Temp  |                    |         | 260     | °C    | MSL level1. Refer to soldering reflow profile in Figure 7 |
| Supply Voltage         | V <sub>DD3</sub>   | -0.5    | 3.4     | V     |                                                           |
|                        | V <sub>DD1_8</sub> | -0.5    | 2.1     | V     |                                                           |
|                        | V <sub>DDIO</sub>  | -0.5    | 3.4     | V     |                                                           |
| ESD (Human body model) |                    |         | 2       | kV    | All Pins                                                  |
| Input Voltage          | V <sub>IN</sub>    | -0.5    | 3.4     | V     | All I/O Pins                                              |

#### Comments:

- Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are the stress ratings only and functional operation of the device at these or any other condition beyond those indicated for extended period of time may affect device reliability.
- The inherent design of this component causes it to be sensitive to electrostatic discharge. The ESD threshold is listed above. To prevent ESD-induced damage, take adequate ESD precautions when handling this product

### Recommended Operating Conditions

| Parameter                                         | Symbol              | Minimum | Typical | Maximum | Units             | Notes                                           |
|---------------------------------------------------|---------------------|---------|---------|---------|-------------------|-------------------------------------------------|
| Operating Temperature                             | T <sub>A</sub>      | 0       |         | 40      | °C                |                                                 |
| Power supply voltage                              | V <sub>DD1_8</sub>  | 1.7     | 1.8     | 2.0     | Volts             | Including noise.                                |
|                                                   | V <sub>DD3</sub>    | 2.7     | 2.8     | 3.3     | Volts             | Including noise.                                |
|                                                   | V <sub>DD5</sub>    | 4.0     | 5.0     | 5.25    | Volts             | Including noise.                                |
|                                                   | V <sub>DD-LED</sub> | 2.7     | 2.8     | 3.3     | Volts             | Including noise.                                |
|                                                   | V <sub>DDIO</sub>   | 1.65    |         | 3.3     | Volts             | Including noise.                                |
| Power supply rise time                            | V <sub>RT1_8</sub>  | 1       |         | 100     | ms                | 0 to 1.8V                                       |
|                                                   | V <sub>RT3</sub>    | 1       |         | 100     | ms                | 0 to 2.8V                                       |
| Supply noise (Sinusoidal)                         | V <sub>NA</sub>     |         |         | 100     | mV <sub>p-p</sub> | 10kHz-50MHz                                     |
| Serial Port Clock Frequency                       | f <sub>SCLK</sub>   |         |         | 2       | MHz               | Active drive, 50% duty cycle                    |
| Distance from lens reference plane to surface (Z) | Z                   | 2.7     | 2.9     | 3.1     | mm                | Results in +/- 0.2 mm minimum DOF. See Figure 5 |
| Speed                                             | S                   |         |         | 200     | ips               |                                                 |
| Lift Cutoff (Manual Calibration)                  | L <sub>C</sub>      |         | 1       | 2.0     | mm                |                                                 |
| Lift Cutoff (Default)                             | L <sub>wc</sub>     |         | 3       |         | mm                |                                                 |
| Acceleration                                      | A                   |         |         | 50      | g                 | In Run Mode only (machine tested upto 30g)      |
| Load Capacitance                                  | C <sub>out</sub>    |         |         | 100     | pF                | MOTION, MISO                                    |

## DC Electrical Specifications

Electrical Characteristics over recommended operating conditions. (Typical values at 25 °C,  $V_{DD3} = 2.8\text{ V}$ ,  $V_{DDIO} = 2.8\text{ V}$ ,  $V_{DD1.8} = 1.8\text{ V}$ )

| Parameter                         | Symbol           | Minimum          | Typical | Maximum          | Units         | Notes                                                                                       |
|-----------------------------------|------------------|------------------|---------|------------------|---------------|---------------------------------------------------------------------------------------------|
| DC Supply Current                 | $I_{DD\_RUN3k}$  |                  | 14      |                  | mA            | Average current, including 10mA LED current. No load on MISO, MOTION.                       |
|                                   | $I_{DD\_RUN7k}$  |                  | 26      |                  | mA            |                                                                                             |
|                                   | $I_{DD\_RUN12k}$ |                  | 38      |                  | mA            |                                                                                             |
|                                   | $I_{DD\_REST1}$  |                  | 0.30    |                  | mA            | RUN3k = run mode at 3000fps<br>RUN7k = run mode at 7000fps<br>RUN12k = run mode at 12500fps |
|                                   | $I_{DD\_REST2}$  |                  | 0.15    |                  | mA            |                                                                                             |
|                                   | $I_{DD\_REST3}$  |                  | 0.08    |                  | mA            |                                                                                             |
| Peak Supply Current               | $I_{DDPP}$       |                  |         | 65               | mA            |                                                                                             |
| Shutdown Supply Current           | $I_{DDSTDWN}$    |                  | 65      |                  | $\mu\text{A}$ | NCS, SCLK, MOSI = VDDIO<br>MISO = GND                                                       |
| Input Low Voltage                 | $V_{IL}$         |                  |         | $0.3 * V_{DDIO}$ | V             | SCLK, MOSI, NCS                                                                             |
| Input High Voltage                | $V_{IH}$         | $0.7 * V_{DDIO}$ |         |                  | V             | SCLK, MOSI, NCS                                                                             |
| Input Hysteresis                  | $V_{I\_HYS}$     |                  | 100     |                  | mV            | SCLK, MOSI, NCS                                                                             |
| Input Leakage Current             | $I_{leak}$       |                  | $\pm 1$ | $\pm 10$         | $\mu\text{A}$ | $V_{in} = 0.7 * V_{DDIO}$ , SCLK, MOSI, NCS                                                 |
| Output Low Voltage, MISO, MOTION  | $V_{OL}$         |                  |         | $0.3 * V_{DDIO}$ | V             | $I_{out} = 1\text{ mA}$ , MISO, MOTION                                                      |
| Output High Voltage, MISO, MOTION | $V_{OH}$         | $0.7 * V_{DDIO}$ |         |                  | V             | $I_{out} = -1\text{ mA}$ , MISO, MOTION                                                     |
| Input Capacitance                 | $C_{in}$         |                  |         | 10               | pF            | MOSI, NCS, SCLK                                                                             |

## Registers

The SDNS-3988 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                     | Read/Write | Default Value |
|-----------|------------------------------|------------|---------------|
| 0x00      | Product_ID                   | R          | 0x3d          |
| 0x01      | Revision_ID                  | R          | 0x01          |
| 0x02      | Motion                       | R          | 0x20          |
| 0x03      | Delta_X_L                    | R          | 0x00          |
| 0x04      | Delta_X_H                    | R          | 0x00          |
| 0x05      | Delta_Y_L                    | R          | 0x00          |
| 0x06      | Delta_Y_H                    | R          | 0x00          |
| 0x07      | SQUAL                        | R          | 0x00          |
| 0x08      | Pixel_Sum                    | R          | 0x00          |
| 0x09      | Maximum_Pixel                | R          | 0x00          |
| 0x0a      | Minimum_Pixel                | R          | 0x00          |
| 0x0b      | Shutter_Lower                | R          | 0x7a          |
| 0x0c      | Shutter_Upper                | R          | 0x31          |
| 0x0d      | Frame_Period_Lower           | R          | 0x1a          |
| 0x0e      | Frame_Period_Upper           | R          | 0x41          |
| 0x0f      | Configuration_I              | R/W        | 0x24          |
| 0x10      | Configuration_II             | R/W        | 0x00          |
| 0x11      | Configuration_III            | R/W        | 0x00          |
| 0x12      | Frame_Capture                | R/W        | 0x00          |
| 0x13      | SROM_Enable                  | W          | 0x00          |
| 0x14      | Run_Downshift                | R/W        | 0x32          |
| 0x15      | Rest1_Rate                   | R/W        | 0x01          |
| 0x16      | Rest1_Downshift              | R/W        | 0x1f          |
| 0x17      | Rest2_Rate                   | R/W        | 0x09          |
| 0x18      | Rest2_Downshift              | R/W        | 0xbc          |
| 0x19      | Rest3_Rate                   | R/W        | 0x31          |
| 0x1a      | Frame_Period_Max_Bound_Lower | R/W        | 0x1a          |
| 0x1b      | Frame_Period_Max_Bound_Upper | R/W        | 0x41          |
| 0x1c      | Frame_Period_Min_Bound_Lower | R/W        | 0xa0          |
| 0x1d      | Frame_Period_Min_Bound_Upper | R/W        | 0x0f          |
| 0x1e      | Shutter_Max_Bound_Lower      | R          | 0x7a          |
| 0x1f      | Shutter_Max_Bound_Upper      | R          | 0x31          |
| 0x24      | Observation                  | R/W        | 0x00          |
| 0x25      | Data_Out_Lower               | R          | Undefined     |
| 0x26      | Data_Out_Upper               | R          | Undefined     |
| 0x27-0x29 | Reserved                     |            |               |
| 0x2a      | SROM_ID                      | R          | 0x00          |
| 0x2b-0x2e | Reserved                     |            |               |
| 0x2f      | Configuration_V              | R/W        | 0x00          |

| Address   | Register                    | Read/Write | Default Value |
|-----------|-----------------------------|------------|---------------|
| 0x30-0x38 | Reserved                    |            |               |
| 0x39      | Configuration_IV            | R/W        | 0x00          |
| 0x3a      | Power_Up_Reset              | W          | NA            |
| 0x3b      | Shutdown                    | W          | NA            |
| 0x3c-0x3e | Reserved                    |            |               |
| 0x3f      | Inverse_Product_ID          | R          | 0xc2          |
| 0x40-0x41 | Reserved                    |            |               |
| 0x42      | Snap_Angle                  | R/W        | 0x06          |
| 0x43-0x46 | Reserved                    |            |               |
| 0x47      | Sensor_Mode                 | R/W        | 0x01          |
| 0x48-0x4f | Reserved                    |            |               |
| 0x50      | Motion_Burst                | R          | 0x00          |
| 0x51-0x63 | Reserved                    |            |               |
| 0x54      | Filter_Configuration        | R/W        | 0x80          |
| 0x55-0x58 | Reserved                    |            |               |
| 0x59      | VFR_Shutter_Max_Bound_Lower | W          | NA            |
| 0x5a      | VFR_Shutter_Max_Bound_Upper | W          | NA            |
| 0x5b      | Reserved                    |            |               |
| 0x5c      | ManCal_Configuration        | R/W        | 0x00          |
| 0x5d      | ManCal_Min_Squal            | R          | NA            |
| 0x5e      | ManCal_Max_Shutter_Lower    | R          | NA            |
| 0x5f      | ManCal_Max_Shutter_Upper    | R          | NA            |
| 0x60-0x61 | Reserved                    |            |               |
| 0x62      | SROM_Load_Burst             | W          | NA            |
| 0x63      | Reserved                    |            |               |
| 0x64      | Pixel_Burst                 | R          | 0x00          |