Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

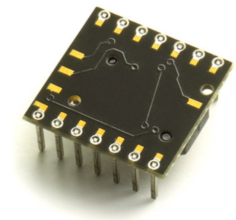
Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

ADNS-6530
Integrated COB LaserStream sensor

AVAGO TECHNOLOGIES

Data Sheet

Lead (Pb) Free
RoHS 6 fully
compliant



Description

The Avago Technologies ADNS-6530 integrated Chip-con-board (COB) LaserStream sensor along with the ADNS-6150 (SFF) lens form a complete and compact laser mouse tracking system. It is the laser-illuminated small form factor (SFF) navigation system. Targeted at cordless applications. The chip integrates the sensor and VCSEL into a single package, providing a small form factor. This new opto-mechanical architecture allows for more compact and cost-effective mouse designs. Powered by latest Avago Technologies LaserStreamTM engine, the mouse can track on more than traditional LED-based optical navigation, especially on glossy and reflective ones. In addition, the high-performance, low power architecture is capable of sensing high-speed mouse motion while prolonging battery life-two performance areas essential in demanding cordless applications.

There is no moving part in the complete assembly for ADNS-6530 laser mouse system, thus it is high reliability and less maintenance for the end user. In addition, precision optical alignment is not required, facilitating high volume assembly.

Theory of Operation

The ADNS-6530 integrated COB LaserStream sensor comprises of sensor and VCSEL in a single package.

The advanced class of VCSEL was engineered by Avago Technologies to provide a laser diode with a single longitudinal and a single transverse mode. In contrast to most oxide-based single-mode VCSEL, this class of Avago Technologies VCSEL remains within single mode operation over a wide range of output power. It has significantly lower power consumption than a LED. It is an excellent choice for optical navigation applications.

The sensor is based on LaserStream™ technology, which 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 Δx and Δy relative displacement values. An external microcontroller reads the Δx and Δy 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

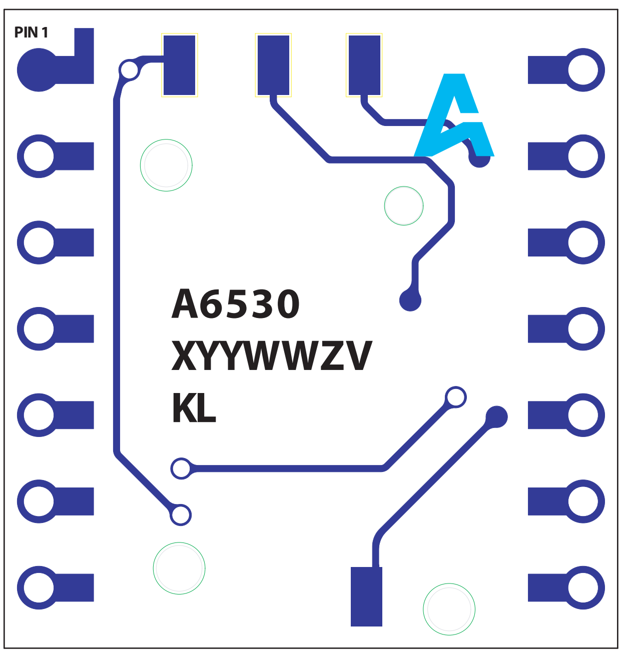
- Small form factor, integrated chip-on-board package
- Low power architecture
- New LaserStream technology
- Self-adjusting power-saving modes for longest battery life
- High speed motion detection up to 20 ips and 8g
- Enhanced SmartSpeed self-adjusting frame rate for optimum performance
- Motion detect pin output
- Internal oscillator – no clock input needed
- Selectable 400 and 800 cpi resolution
- Wide operating voltage: 2.7V-3.6V nominal
- Four wire serial port
- Minimal number of passive components
- Laser fault detect circuitry on-chip for Eye Safety Compliance
- Advanced Technology VCSEL chip
- Single Mode Lasing operation
- 832-865 nm wavelength

Applications

- Laser Mice
- Optical trackballs
- Integrated input devices
- Battery-powered input devices

Pinout of ADNS-6530 Optical Mouse Sensor

Pin	Name	Description
1	-VCSEL	Negative Terminal of VCSEL
2	NCS	Chip select (active low input)
3	MISO	Serial data output (Master In/Slave Out)
4	SCLK	Serial clock input
5	MOSI	Serial data input (Master Out/Slave In)
6	MOTION	Motion Detect (active low output)
7	LASER_NEN	LASER Enable (Active LOW)
8	AVDD	Analog Supply Voltage
9	AGND	Analog Ground
10	GND	Ground
11	GND	Ground
12	GND	Ground
13	VDD	Supply Voltage
14	+VCSEL	Positive Terminal of VCSEL



X = Subcon code
YYWW = Date code
Z = Sensor Die Source
V = VCSEL Die Source
KL = VCSEL Binning (2A, 3A)

Figure 1. Package outline drawing (top view)

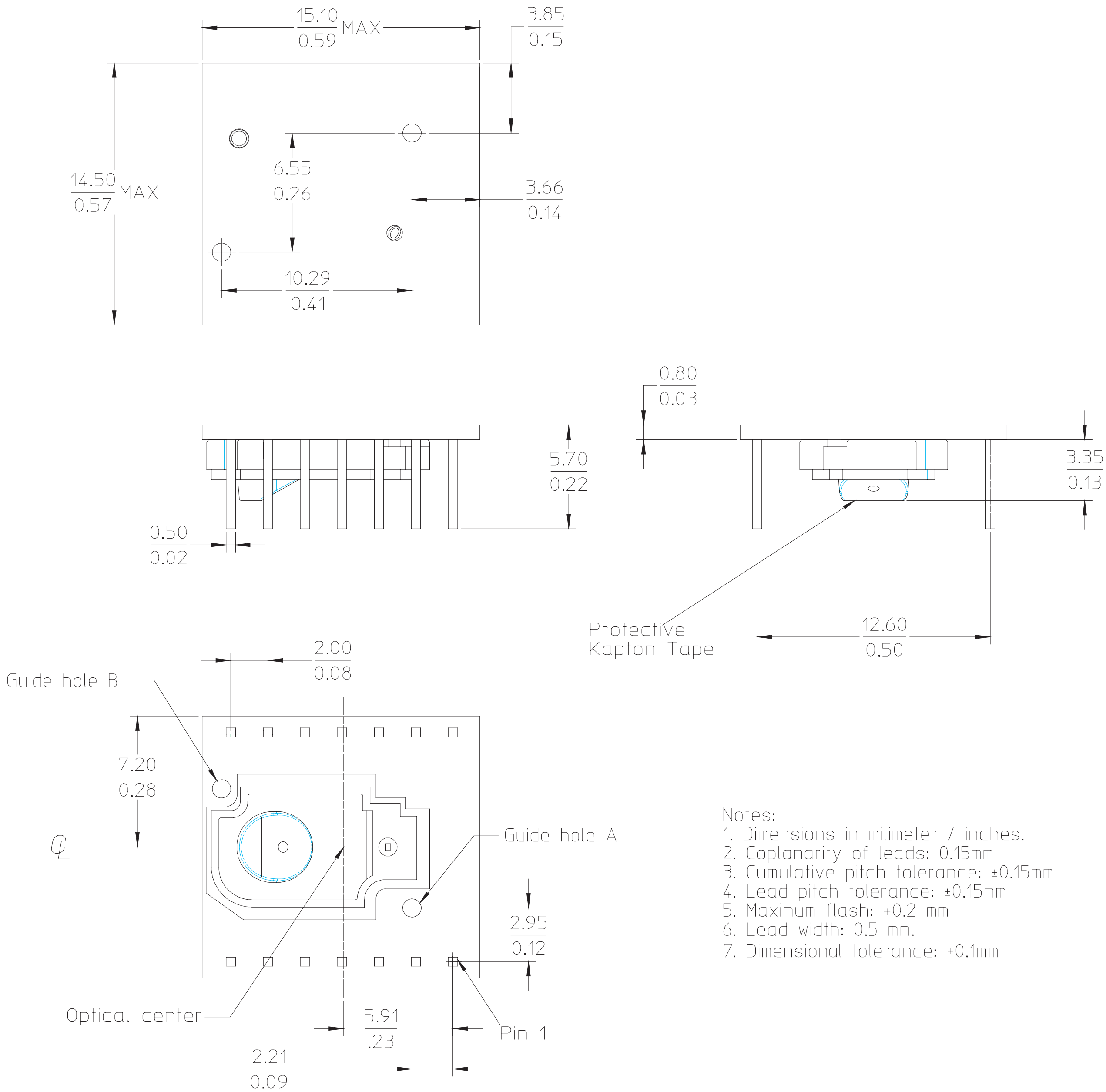
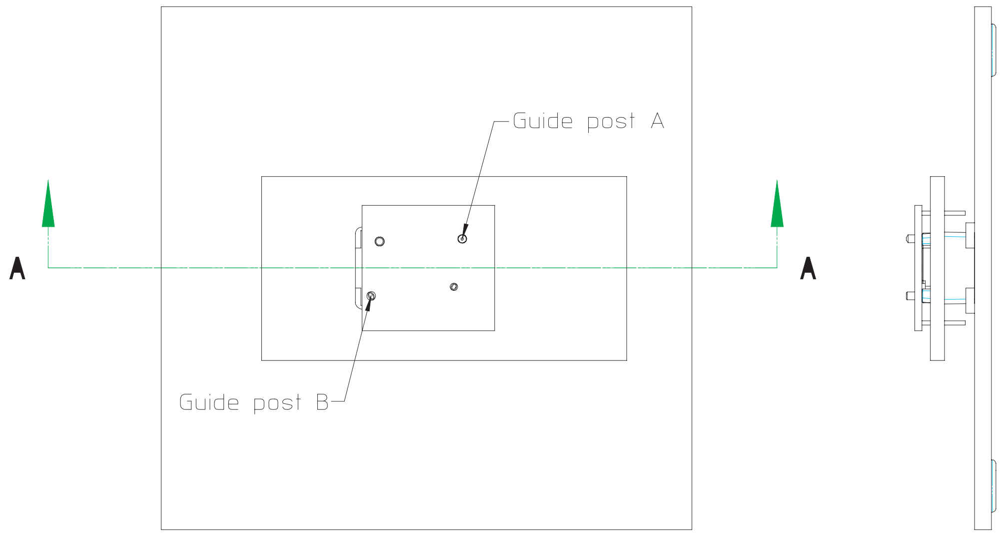


Figure 2. Package outline drawing

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

Overview of Laser Mouse Sensor Assembly



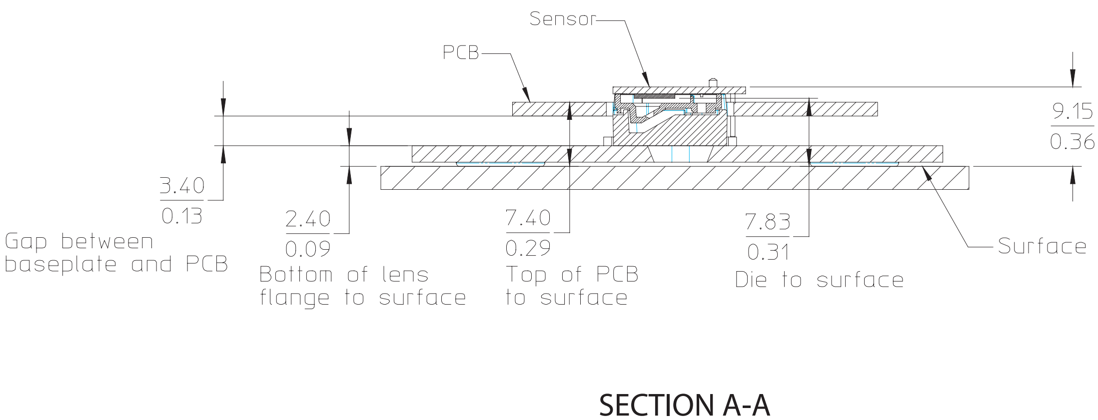


Figure 3. 2D Assembly Drawing of ADNS-6530, PCBs and Base Plate

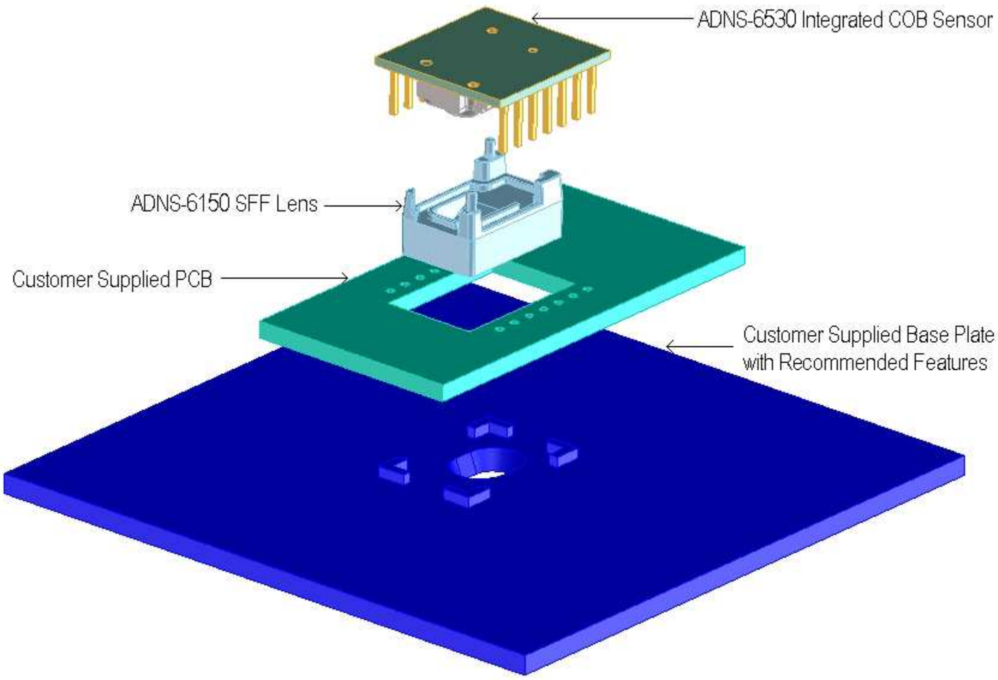


Figure 4. Exploded view drawing

Shown with ADNS-6530 integrated COB LaserStream sensor and ADNS-6150 SFF lens, the components self-align as they are mounted onto defined features on the base plate.

The ADNS-6530 integrated COB LaserStream sensor is designed for mounting on a through-hole PCB, looking down. There are an aperture stop and guide holes on the package that align to the ADNS-6150 SFF lens.

The VCSEL is used for illumination, provides a laser diode with a single longitudinal and a single transverse mode. It is particularly suited as lower power consumption and highly coherent replacement of LEDs. It also provides wider operation range while still remaining within single-mode, reliable operating conditions.

The ADNS-6150 SFF lens is designed for use with ADNS-6530 integrated COB LaserStream sensor. The VCSEL contained in the package and the lens provides the directed illumination and optical imaging necessary for proper operation of the sensor. ADNS-6150 SFF lens is precision molded optical components and should be handled with care to avoid scratching of the optical surfaces.

Avago Technologies provides a STEP or IGES file drawing describing the base plate molding features for lens and PCB alignment.

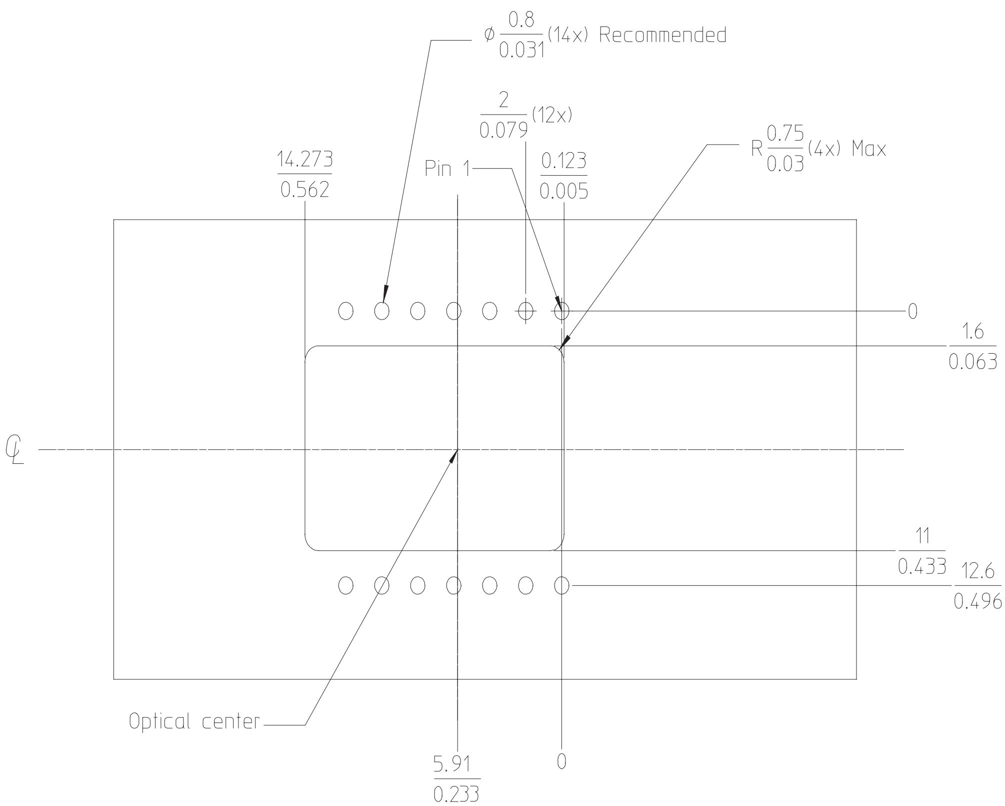


Figure 5. Recommended PCB mechanical cutouts and spacing

Assembly Recommendation

1. Insert the integrated COB LaserStream sensor and all other electrical components into the application PCB.
2. Wave-solder the entire assembly in a no-wash solder process utilizing a 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 there is no stopper feature on the lead to rest the package 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.
3. Place the lens onto the base plate. Care must be taken to avoid contamination on the optical surfaces.
4. Remove the protective kapton tapes from the optical apertures of the sensor and VCSEL respectively. Care must be taken to keep contaminants from entering the apertures.
5. Insert the PCB assembly over the lens onto the base plate. The sensor package should self-align to the lens. The optical position reference for the PCB is set by the base plate and lens. The alignment guide post of the lens locks the lens and integrated COB LaserStream sensor together. Note that the PCB motion due to button presses must be minimized to maintain optical alignment.
6. Optional: The lens can be permanently locked to the sensor package by melting the lens' guide posts over the sensor with heat staking process.
7. Tune the laser output power from the VCSEL to meet the Eye Safe Class I Standard as detailed in the LASER Power Adjustment Procedure.
8. Install the mouse top case. There must be a feature in the top case (or other area) to press down onto the sensor to ensure the sensor and lens are interlocked to the correct vertical height.

Design considerations for improving ESD Performance

For improved electrostatic discharge performance, typical creepage and clearance distance are shown in the table below. Assumption: base plate construction as per the Avago Technologies supplied STEP or IGES file and ADNS-6150 lens:

Typical Distance	Millimeters
Creepage	12.1*
Clearance	2.0

* Inclusive of the 2.4mm typical distance from lens reference plane to surface, Z (equivalent to baseplate and foot-pads thickness). Exclusive of the 2.4mm, creepage = 9.7mm

Note that the lens material is polycarbonate and therefore, cyanoacrylate based adhesives or other adhesives that may damage the lens should NOT be used.

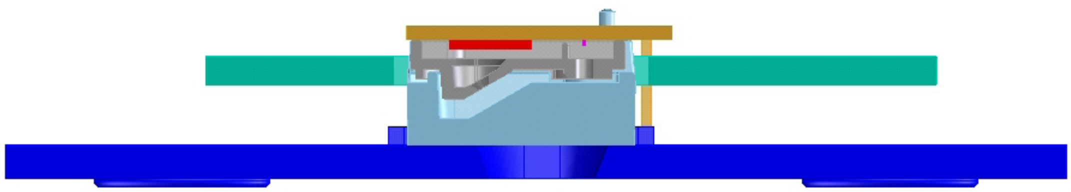


Figure 6. Sectional view of PCB assembly highlighting optical mouse components

Application Circuit

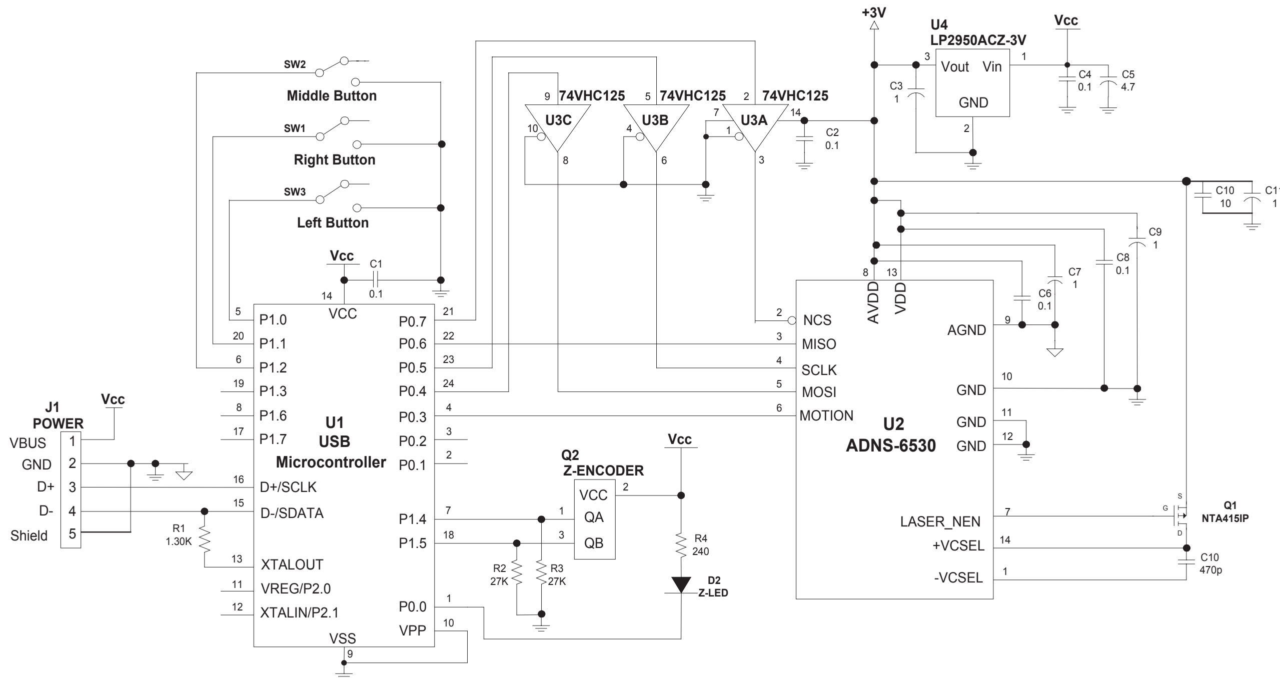


Figure 7a. Schematic Diagram for 3-Button Scroll Wheel Corded Mouse

Notes

- The supply and ground paths should be laid out using a star methodology.
- Level shifting is required to interface a 5V micro-controller to the ADNS-6530. If a 3V micro-controller is used, the 74VHC125 component shown may be omitted.
- All the caps must be placed as near as possible to the ADNS-6530, micro-controller and RF ICs for noise filtering.

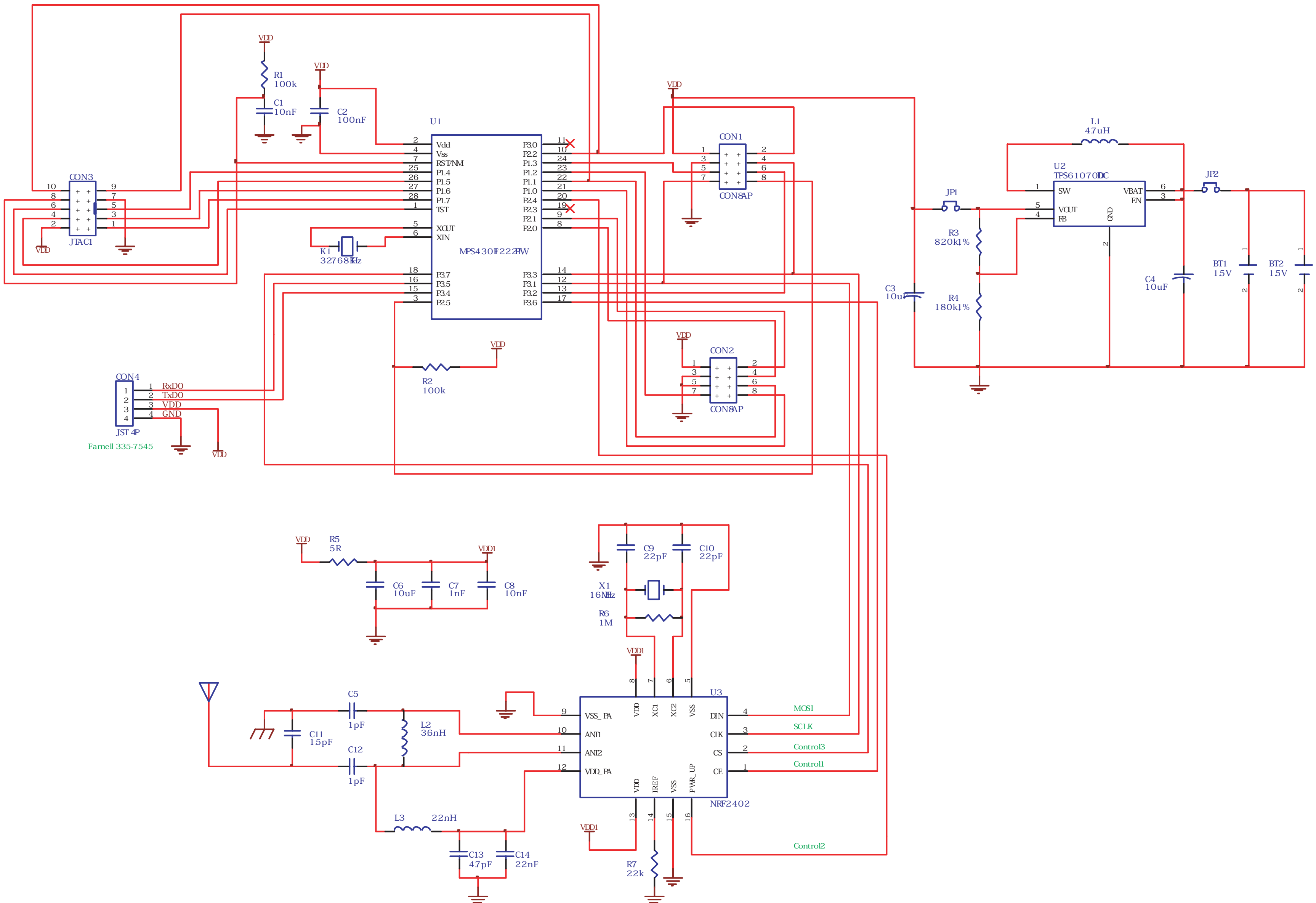


Figure 7b. Schematic Diagram for 3-Button Scroll Wheel Cordless Mouse

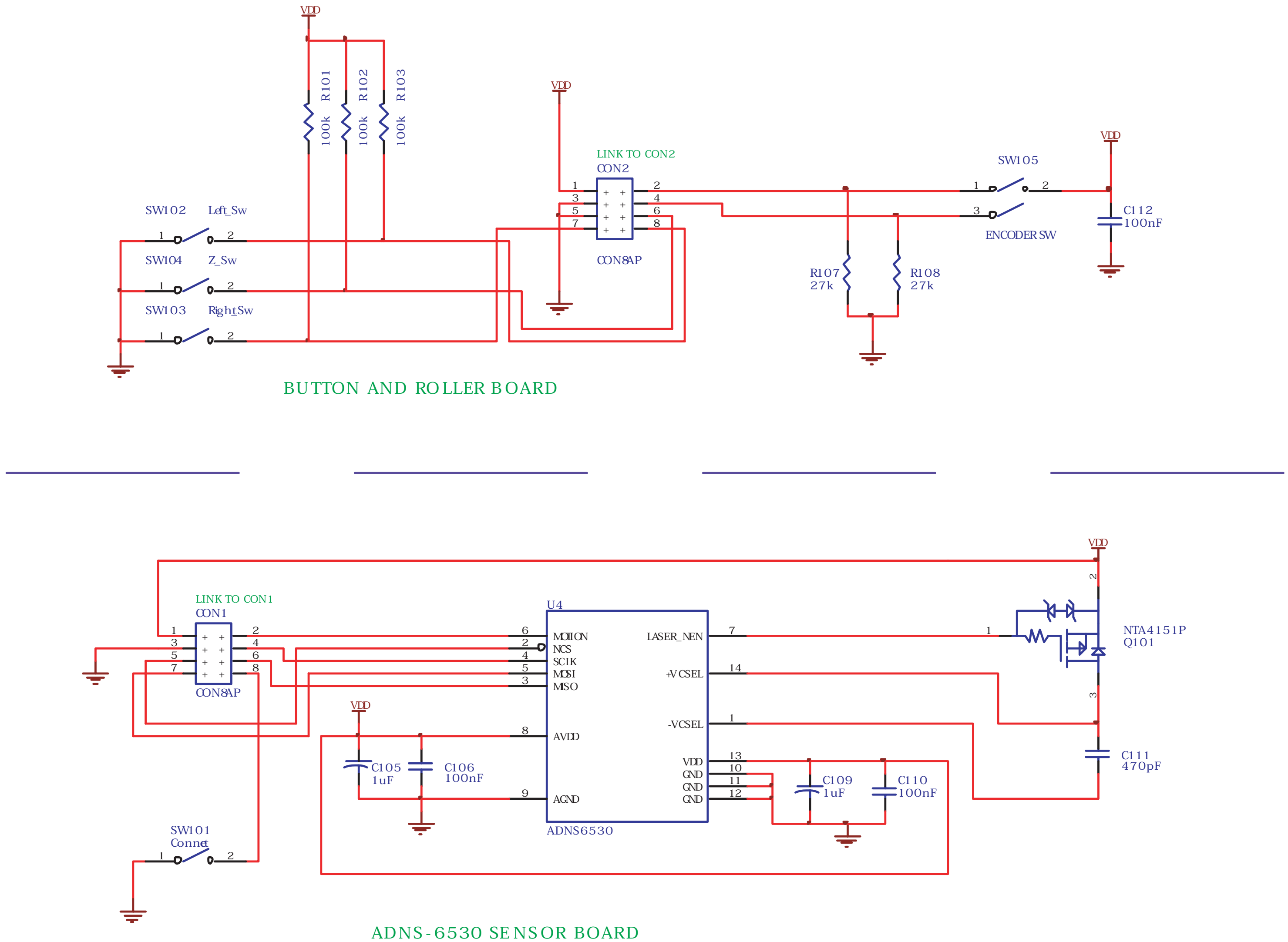


Figure 7c. Schematic Diagram for 3-Button Scroll Wheel Cordless Mouse

Eye Safety

The ADNS-6530 integrated COB LaserStream sensor and the associated components in the schematic of Figure 5 are intended to comply with Class 1 Eye Safety Requirements of IEC 60825-1. Avago Technologies suggests that manufacturers perform testing to verify eye safety on each mouse. It is also recommended to review possible single fault mechanisms beyond those described below in the section "Single Fault Detection". Under normal conditions, the sensor generates the drive current for the VCSEL.

In order to stay below the Class 1 power requirements, LASER_CTRL0 (register 0x1a), LASER_CTRL1 (register 0x1f), LSRPWR_CFG0 (register 0x1c) and LSRPWR_CFG1 (register 0x1d) must be programmed to appropriate values. The ADNS-6530 integrated COB LaserStream sensor which comprised of the sensor and VCSEL; is designed to maintain the output beam power within Class 1 requirements over components manufacturing tolerances and the recommended temperature range when adjusted per the procedure below and implemented as shown in the recommended application circuit of Figure 7. For more information, please refer to Eye Safety Application Note AN5297.

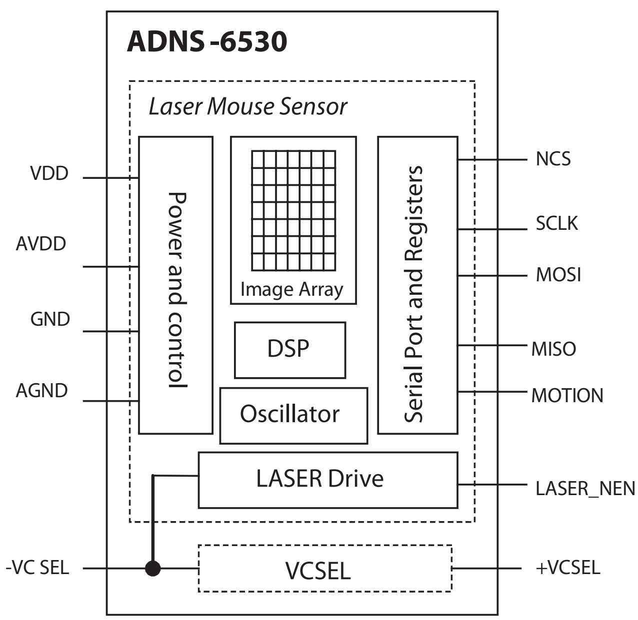


Figure 8. Block diagram of ADNS-6530 integrated COB LaserStream sensor

LASER Drive Mode

The laser is driven in pulsed mode during normal operation. A calibration mode is provided which drives the laser in continuous (CW) operation.

LASER Power Adjustment Procedure

1. The ambient temperature should be 25°C ± 5°C.
2. Set VDD to its permanent value.
3. Set the Range bit (bit 7 of register 0x1a) to 0.
4. Set the Range_C complement bit (bit 7 of register 0x1f) to 1.
5. Enable the Calibration mode by writing to bits [3,2,1] of register 0x1A so the laser will be driven with 100% duty cycle.
6. Write the Calibration mode complement bits to register 0x1f.
7. Set the laser current to the minimum value by writing 0x00 to register 0x1c, and the complementary value 0xFF to register 0x1d.
8. Program registers 0x1c and 0x1d with increasing values to achieve an output power as close to 506uW as possible without exceeding it. If this power is obtained, the calibration is complete, skip to step 12.
9. If it was not possible to achieve the power target, set the laser current to the minimum value by writing 0x00 to register 0x1c, and the complementary value 0xff to register 0x1d.
10. Set the Range and Range_C bits in registers 0x1a and 0x1f, respectively, to choose to the higher laser current range.
11. Program registers 0x1c and 0x1d with increasing values to achieve an output power as close to 506uW as possible without exceeding it.
12. Save the value of registers 0x1a, 0x1c, 0x1d, and 0x1f in non-volatile memory in the mouse. These registers must be restored to these values every time the ADNS-6530 is reset.
13. Reset the mouse, reload the register values from non-volatile memory, enable Calibration mode, and measure the laser power to verify that the calibration is correct.

Good engineering practices such as regular power meter calibration, random quality assurance retest of calibrated mice, etc. should be used to guarantee performance, reliability and safety for the product design.

Parameter	Symbol	Minimum	Maximum	Units	Notes
Laser output power	LOP		716	uW	Class 1 limit with recommended VCSEL and lens.

LASER Output Power

The laser beam output power as measured at the navigation surface plane is specified below. The following conditions apply:

1. The system is adjusted according to the above procedure.
2. The system is operated within the recommended operating temperature range.
3. The VDD value is no greater than 300mV above its value at the time of adjustment.
4. No allowance for optical power meter accuracy is assumed.

Disabling the LASER

LASER_NEN is connected to the gate of a P-channel MOSFET transistor which when ON connects VDD to the LASER. In normal operation, LASER_NEN is low. In the case of a fault condition (ground or VDD at –VCSEL), LASER_NEN goes high to turn the transistor off and disconnect VDD from the LASER.

Single Fault Detection

ADNS-6530 is able to detect a short circuit or fault condition at the –VCSEL pin, which could lead to excessive laser power output. A path to ground on this pin will trigger the fault detection circuit, which will turn off the laser drive current source and set the LASER_NEN output high. When used in combination with external components as shown in the block diagram below, the system will prevent excess laser power for a resistive path to ground at –VCSEL by shutting off the laser. In addition to the ground path fault detection described above, the fault detection circuit is continuously checked for proper operation by internally generating a path to ground with the laser turned off via LASER_NEN. If the –VCSEL pin is shorted to VDD, this test will fail and will be reported as a fault.

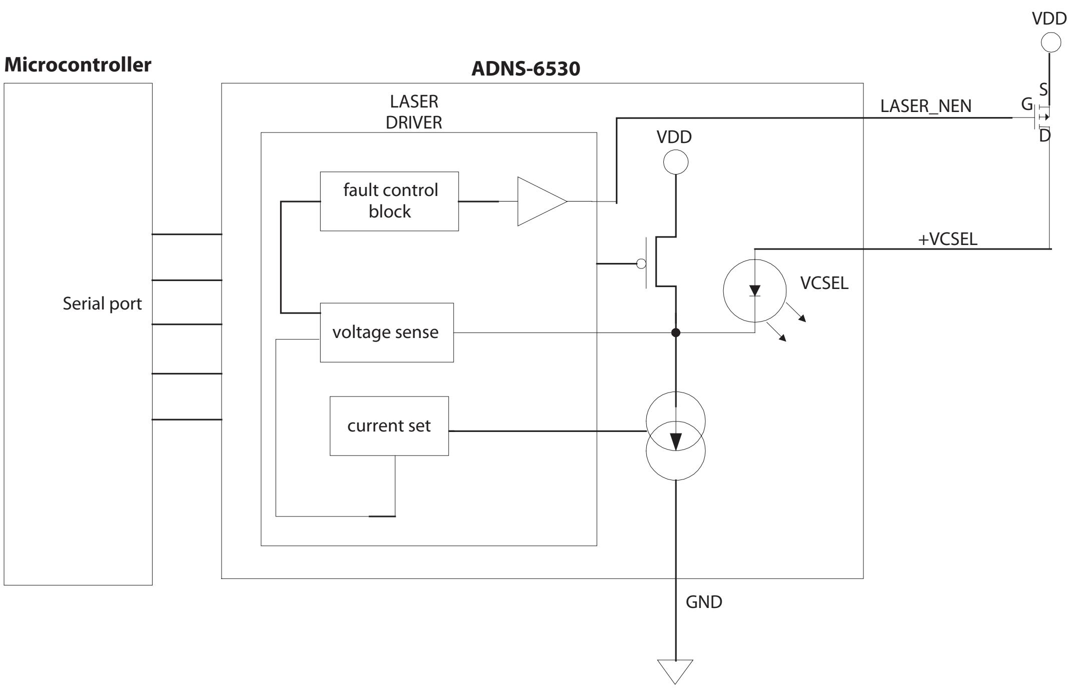


Figure 9. Single Fault Detection and Eye-safety Feature Block Diagram

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.
- Passes EN61000-4-4/IEC801-4 EFT tests when assembled into a mouse with shielded cable and following Avago Technologies recommendations.
- UL flammability level UL94 V-0.
- Provides sufficient ESD creepage/clearance distance to avoid discharge up to 15kV when assembled into a mouse according to usage instructions above.

Absolute Maximum Ratings

VCSEL Die Source Marking	V = A,V	V = C		
Parameter	**Max**	**Max**	**Units**	**Notes**
DC Forward current	12	7.0	mA	
Peak Pulsing current	19	9	mA	Duration = 100ms, 10% duty cycle
Power Dissipation	24	24	mW	
Reverse voltage	5	8	V	I = 10µA
Laser Junction Temperature	150	170	ºC	
Operating case Temperature	5 to 45	5 to 45	ºC	
Storage case Temperature	-40 to +85	-40 to +85	ºC	
Lead Soldering Temperature	260	260	ºC	See reflow profile (Figure 10)
ESD (Human-body model)	2	2	kV	

Comments:

1. 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.
2. The maximum ratings do not reflect eye-safe operation. Eye safe operating conditions are listed in the power adjustment procedure section.
3. 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.

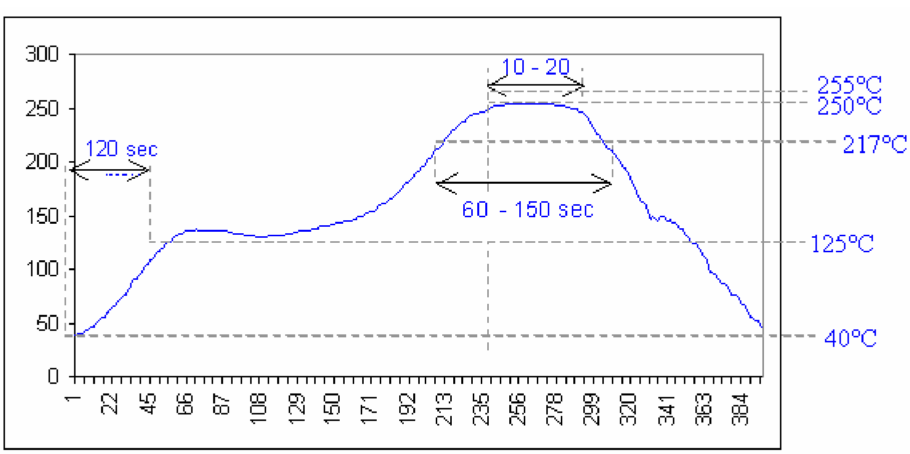


Figure 10. Recommended Soldering Reflow Profile

Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Operating Temperature	T_A	5		40	°C	
Power supply voltage	V_{DD}	2.7	2.8	3.6	Volts	Including noise.
Power supply rise time	V_{RT}	1		100	µsms	0 to 2.8V
Supply noise (Sinusoidal)	V_{NA}			100	mV_{p-p}	10kHz-50MHz
Serial Port Clock Frequency	f_{SCLK}			1	MHz	Active drive, 50% duty cycle
Distance from lens reference plane to surface	Z	2.18	2.40	2.62	mm	Results in +/- 0.22 mm minimum DOF. See Figure 11
Speed	S			20	in/sec	
Acceleration	A			8	g	
Load Capacitance	C_{out}			100	pF	MOTION, MISO
Voltage at -VCSEL	V_{-VCSEL}	0.3		V_{DD}	V	

Optical/Electrical Characteristics (at Tc = 5°C to 45°C):

VCSEL Die Source Marking		V = A,V			V = C				
Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Units**	**Notes**
Peak Wavelength	λ	832		865	832		865	nm	
Maximum Radiant Power	LOPmax		4.5			4.0		mW	Maximum output power under any condition. This is not a recommended operating condition and does not meet eye safety require-ments.
Wavelength Tempera-ture coefficient	dλ/dT		0.065			0.065		nm/ºC	
Wavelength Current coefficient	dλ/dI		0.21			0.3		nm/mA	
Beam Divergence	θFW@1/e^2		15			16		deg	
Threshold current	Ith		4.2			3.0		mA	
Slope Efficiency	SE		0.4			0.35		W/A	
Forward Voltage	VF		2.1	2.4		2.1	2.4	V	At 500uW output power

Comments:

1. VCSELs are sorted into bins as specified in the Figure 7. Package outline drawing (top view). Appropriate binning register data values are used in the application circuit to achieve the target output power. The VCSEL binning is marked on the integrated COB LaserStream sensor package.
2. When driven with current or temperature range greater than specified in the power adjustment procedure section, eye safety limits may be exceeded. The VCSEL should then be treated as a Class 3b laser and as a potential eye hazard.

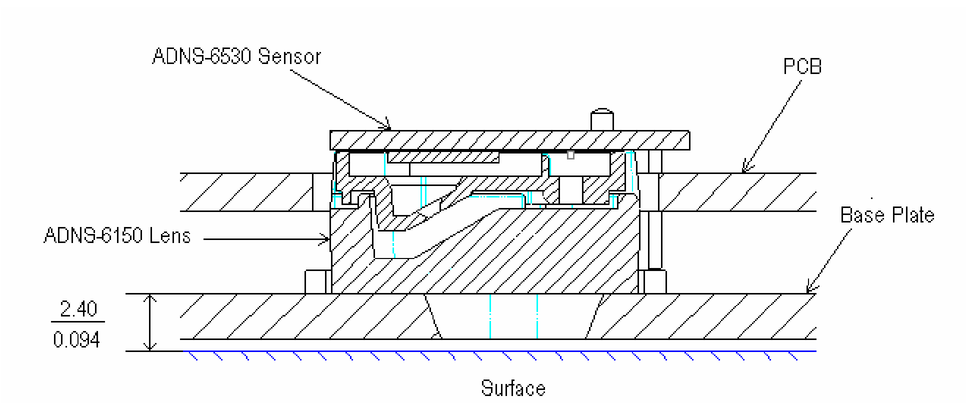


Figure 11. Distance from lens reference plane to surface, Z

AC Electrical Specifications

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

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Motion delay after reset	$t_{MOT-RST}$			23	ms	From SW_RESET register write to valid motion, assuming motion is present
Shutdown	t_{STDWN}			50	ms	From Shutdown mode active to low current
Wake from shut-down	t_{WAKEUP}	23			ms	From Shutdown mode inactive to valid motion. Notes: A RESET must be asserted after a shutdown. Refer to section "Notes on Shutdown and Forced Rest", also note $t_{MOT-RST}$
Forced Rest enable	$t_{REST-EN}$			1	s	From RESTEN bits set to low current
Wake from Forced Rest	$t_{REST-DIS}$			1	s	From RESTEN bits cleared to valid motion
MISO rise time	t_{r-MISO}		150	300	ns	C_L = 100pF
MISO fall time	t_{f-MISO}		150	300	ns	C_L = 100pF
MISO delay after SCLK	$t_{DLY-MISO}$			120	ns	From SCLK falling edge to MISO data valid, no load conditions
MISO hold time	$t_{hold-MISO}$	0.5		$1/f_{SCLK}$	us	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, 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 for 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	$t_{SRW}t_{SRR}$	500			ns	From rising SCLK for last bit of the first data byte, to falling SCLK for the first bit of the address byte of the next command.
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}	500			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 rising 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			us	From last SCLK rising edge to NCS rising edge, for valid MOSI data transfer
NCS to MISO high-Z	$t_{NCS-MISO}$			500	ns	From NCS rising edge to MISO high-Z state
MOTION rise time	$t_{r-MOTION}$		150	300	ns	C_L = 100pF
MOTION fall time	$t_{f-MOTION}$		150	300	ns	C_L = 100pF
Transient Supply Current	I_{DDT}			45	mA	Max supply current during a V_{DD} ramp from 0 to 3.6V

DC Electrical Specifications

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

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
DC Supply Current in various modes	I_{DD_RUN} I_{DD_REST1} I_{DD_REST2} I_{DD_REST3}		4 0.5 0.2 0.06	12 1.8 0.6 0.18	mA	Average current, including LASER current No load on MISO, Motion On black copy surface 500uW laser output power
Peak Supply Current				40	mA	100% LASER current on black copy surface
Shutdown Supply Current	$I_{DDSTDWN}$		1	12	µA	NCS, SCLK = VDDMOSI = GND-MISO = Hi-Z
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}		100		mV	SCLK, MOSI, NCS
Input leakage current	I_{leak}		±1	±10	µA	Vin = V_{DD}-0.6V, SCLK, MOSI, NCS
Current @ (-VCSEL) pin	I_{LAS}	2		8.5	mA	LOP = 500µW
Output Low Voltage, MISO, LASER_NEN	V_{OL}			0.7	V	Iout= 1mA, MISO, MOTIONIout= 1mA, LASER_NEN
Output High Voltage, MISO, LASER_NEN	V_{OH}	V_{DD} - 0.7			V	Iout= -1mA, MISO, MOTIONIout= -0.5mA, LASER_NEN
Input Capacitance	C_{in}			10	pF	MOSI, NCS, SCLK

Sensor's Typical Performance Characteristics

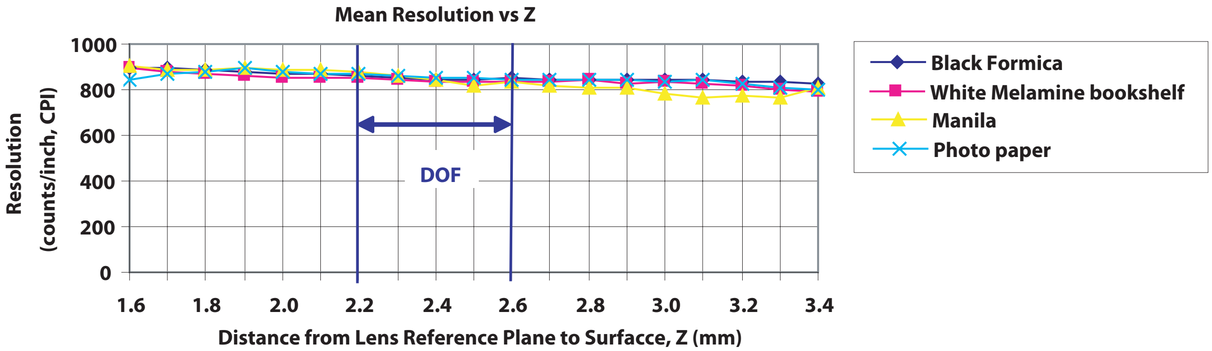


Figure 12. Mean Resolution vs. Z at 800cpi

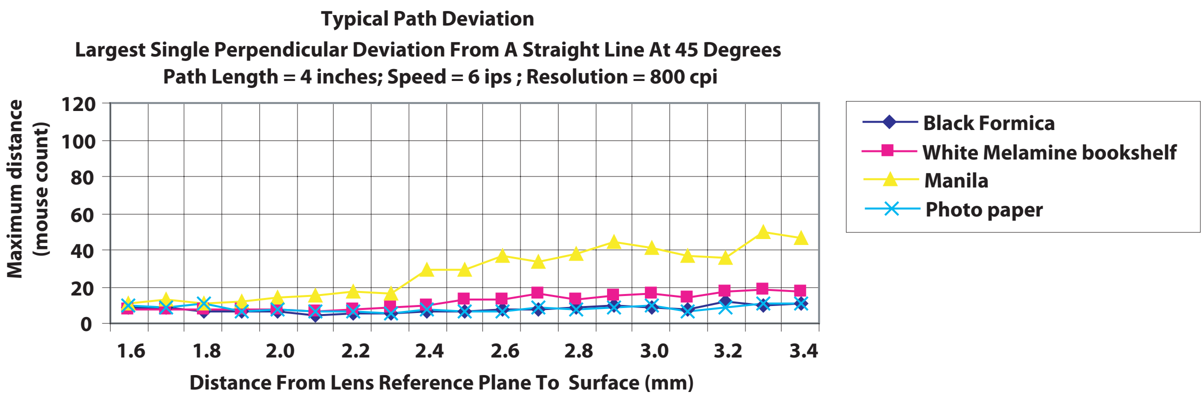


Figure 13. Average Error vs. Distance at 800cpi

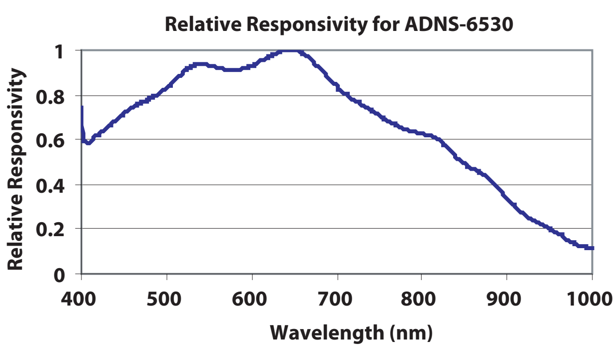


Figure 14. Wavelength Responsivity

VCSEL's Typical Characteristics

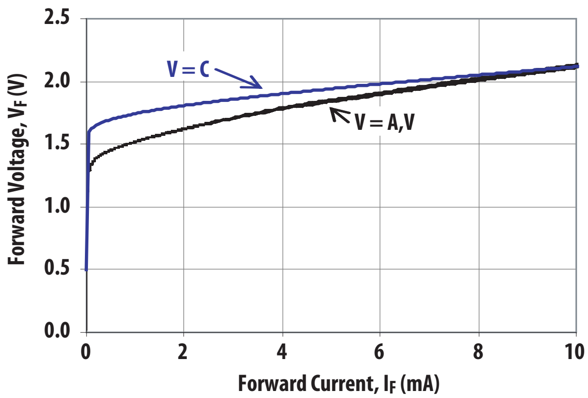


Figure 15. Forward Voltage vs. Forward Current for VCSEL

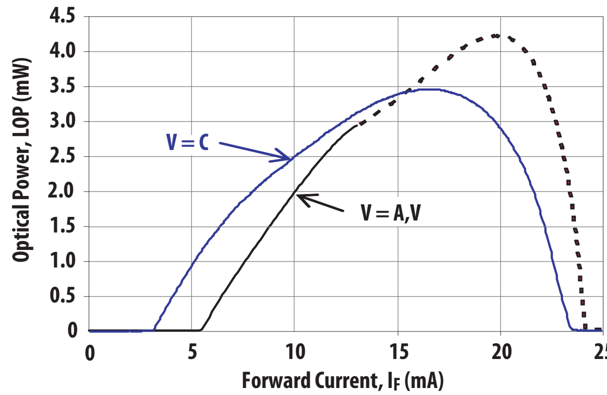


Figure 16. Optical Power vs. Forward Current for VCSEL

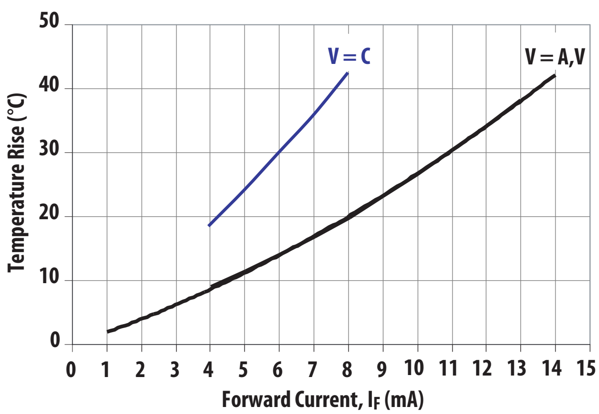


Figure 17. Junction Temperature Rise vs. Forward Current for VCSEL

Power management modes

The ADNS-6530 has three power-saving modes. Each mode has a different motion detection period, affecting response time to mouse motion (Response Time). The sensor automatically changes to the appropriate mode, depending on the time since the last reported motion (Downshift Time). The parameters of each mode are shown in the following table.

Mode	Response Time (nominal)	Downshift Time (nominal)
Rest 1	16.5ms	237ms
Rest 2	82ms	8.4s
Rest 3	410ms	504s

Motion Pin Timing

The motion pin is a level-sensitive output that signals the micro-controller when motion has occurred. The motion pin is lowered whenever the motion bit is set; in other words, whenever there is data in the Delta_X or Delta_Y registers. Clearing the motion bit (by reading Delta_X and Delta_Y, or writing to the Motion register) will put the motion pin high.

LASER Mode

For power savings, the VCSEL will not be continuously on. ADNS-6530 will flash the VCSEL only when needed.

Synchronous Serial Port

The synchronous serial port is used to set and read parameters in the ADNS-6530, and to read out the motion information. The port is a four-wire port. The host micro-controller always initiates communication; the ADNS-6530 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 tri-stated.

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.

Write Operation

Write operation, defined as data going from the micro-controller to the ADNS-6530, 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 data direction. The second byte contains the data. The ADNS-6530 reads MOSI on rising edges of SCLK.

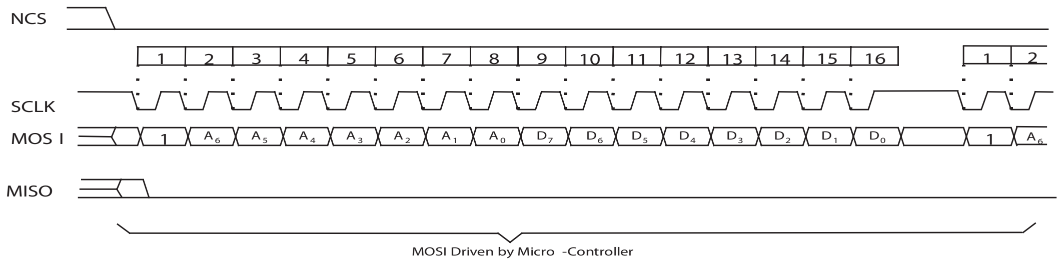


Figure 18. Write Operation

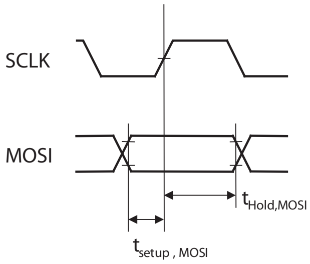


Figure 19. MOSI Setup and Hold Time

Read Operation

A read operation, defined as data going from the ADNS-6530 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-6530 over MISO. The sensor outputs MISO bits on falling edges of SCLK and samples MOSI bits on every rising edge of SCLK.

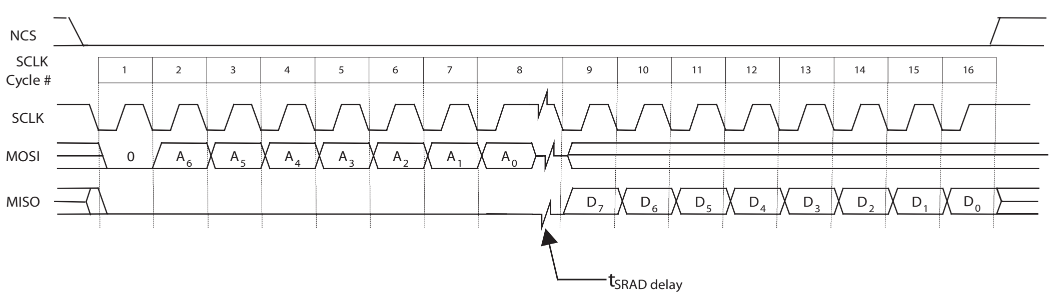


Figure 20. Read Operation

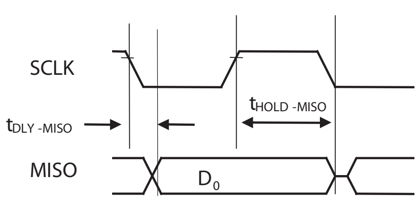


Figure 21. MISO Delay and Hold Time

Note: The 0.5/fSCLK minimums high state of SCLK is also the minimum MISO data hold time of the ADNS-6530. Since the falling edge of SCLK is actually the start of the next read or write command, the ADNS-6530 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.

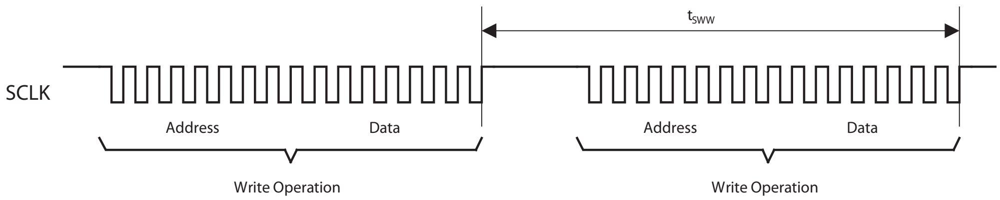


Figure 22. Timing between two write commands

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.

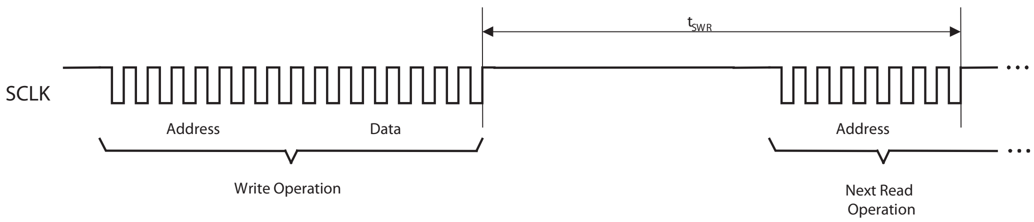


Figure 23. Timing between write and read commands

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.

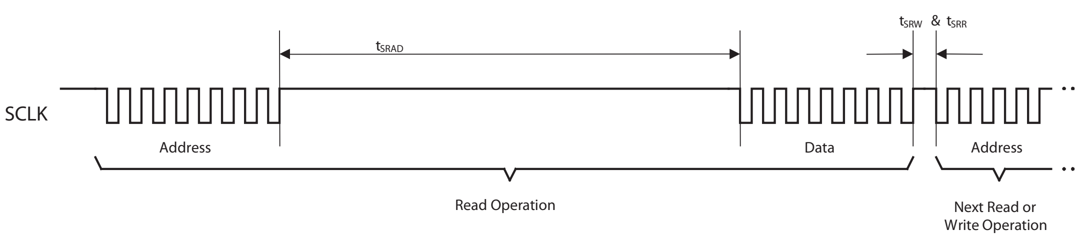


Figure 24. Timing between read and either write or subsequent read commands

During a read operation SCLK should be delayed at least t_{SRAD} after the last address data bit to ensure that the ADNS-6530 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_{SRR} or t_{SRW} after the last SCLK rising edge of the last data bit of the previous read operation.

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 activated by reading the Motion_Burst register. The ADNS-6530 will respond with the contents of the Motion, Delta_X, Delta_Y, SQUAL, Shutter_Upper, Shutter_Lower and Maximum_Pixel registers in that order. The burst transaction can be terminated anywhere in the sequence after the Delta_X value by bringing the NCS pin high. After sending the register address, the micro-controller must wait t_{SRAD} and then begin reading data. 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.

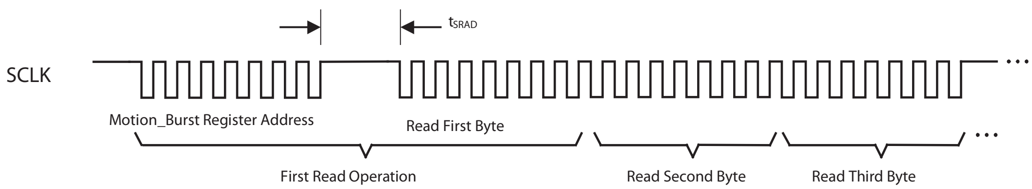


Figure 25. Motion Burst Timing

Notes on Power-up

The ADNS-6530 does not perform an internal power up self-reset; the POWER_UP_RESET register must be written every time power is applied. The appropriate sequence is as follows:

1. Apply power
2. Drive NCS high, then low to reset the SPI port
3. Write 0x5a to register 0x3a
4. Wait for t_{WAKEUP}
5. Write 0xFE to register 0x28
6. Read from registers 0x02, 0x03 and 0x04 (or read these same 3 bytes from burst motion register 0x42) one time regardless of the motion pin state.

During power-up there will be a period of time after the power supply is high but before any clocks are available. The table below shows the state of the various pins during power-up and reset.

State of Signal Pins After VDD is Valid				
Pin	**On Power-Up**	**NCS High before Reset**	**NCS Low before Reset**	**After Reset**
NCS	Functional	High	Low	Functional
MISO	Undefined	Undefined	Functional	Depends on NCS
SCLK	Ignored	Ignored	Functional	Depends on NCS
MOSI	Ignored	Ignored	Functional	Depends on NCS
-VCSEL	Undefined	Undefined	Undefined	Functional
MOTION	Undefined	Undefined	Undefined	Functional
LASER_NEN	Undefined	Undefined	Undefined	Functional

Notes on Shutdown and Forced Rest

The ADNS-6530 can be set in Rest mode through the Configuration_Bits register (0x11). This is to allow for further power savings in applications where the sensor does not need to operate all the time.

The ADNS-6530 can be set in Shutdown mode by writing 0xe7 to register 0x3b. The SPI port should not be accessed when Shutdown mode is asserted, except the power-up command (writing 0x5a to register 0x3a). (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 shutdown. To deassert Shutdown mode:

1. Write 0x5a to register 0x3a
2. Wait for t_{WAKEUP}
3. Write 0xFE to register 0x28
4. Any register settings must then be reloaded.

Pin	Status when Shutdown Mode
NCS	Functional *1
MISO	Undefined *2
SCLK	Ignore if NCS = 1 *3
MOSI	Ignore if NCS = 1 *4
XYLASER	High (off)
LASER_NEN	High (off)
MOTION	Undefined *2

*1 NCS pin must be held to 1 (high) if SPI bus is shared with other devices. It is recommended to hold to 1 (high) during Power Down unless powering up the Sensor. It must be held to 0 (low) if the sensor is to be re-powered up from shutdown (writing 0x5a to register 0x3a).

*2 Depends on last state

*3 SCLK is ignored if NCS is 1 (high). It is functional if NCS is 0 (low).

*4 MOSI is ignored if NCS is 1 (high). If NCS is 0 (low), any command present on the MOSI pin will be ignored except power-up command (writing 0x5a to register 0x3a).

Note: There are long wakeup times from shutdown and forced Rest. These features should not be used for power management during normal mouse motion.

Registers

The ADNS-6530 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	0x20
0x01	Revision_ID	R	0x03
0x02	Motion	R/W	0x00
0x03	Delta_X	R	0x00
0x04	Delta_Y	R	0x00
0x05	SQUAL	R	0x00
0x06	Shutter_Upper	R	0x00
0x07	Shutter_Lower	R	0x64
0x08	Maximum_Pixel	R	0xd0
0x09	Pixel_Sum	R	0x80
0x0a	Minimum_Pixel	R	0x00
0x0b	Pixel_Grab	R/W	0x00
0x0c	CRC0	R	0x00
0x0d	CRC1	R	0x00
0x0e	CRC2	R	0x00
0x0f	CRC3	R	0x00
0x10	Self_Test	W	NA
0x11	Configuration_Bits	R/W	0x03
0x12-0x19	Reserved		
0x1a	LASER_CTRL0	R/W	0x00
0x1d	LSRPWR_CFG1	R/W	0x00
0x1e	Reserved		
0x1f	LASER_CTRL1	R/W	0x01
0x20-0x2d	Reserved		
0x2e	Observation	R/W	0x00
0x2f-0x39	Reserved		
0x3a	POWER_UP_RESET	W	NA
0x3b	Shutdown	W	NA
0x3c-0x3d	Reserved		
0x3e	Inverse_Revision_ID	R	0xfc
0x3f	Inverse_Product_ID	R	0xdf
0x42	Motion_Burst	R	0x00