ADNK-7533-TN24
USB 2.4GHz RF Wireless Laser Mouse Designer's Kit

Design Guide

Lead (Pb) Free
RoHS 6 fully compliant

Introduction

This design guide describes the design of a low power consumption optical mouse using the following components:

- Avago Technologies ADNS-7530 integrated molded lead-frame DIP laser mouse sensor
- Texas Instruments MSP430F1222 microcontroller
- Nordic Semiconductor nRF24L01 and nRF2401A 2.4GHz RF transceivers
- Silicon Laboratories C8051F326 USB microcontroller.

This reference design kit provides a power efficient and feature rich solution in one neat package.

The design guide discusses the reference design hardware and firmware implementation. The document starts with the basic operations of a computer mouse peripheral followed by an introduction to the Avago Technologies ADNS-7530 low power laser mouse sensor, the Nordic Semiconductor nRF24L01 and nRF2401A transceivers, Texas Instruments MSP430F1222 microcontroller and Silicon Laboratories C8051F326 USB controller. The software section of this application note describes the architecture of the firmware required to implement the mouse and the USB dongle functions. Included in Appendix A is the schematic for this reference design mouse and USB dongle.

The Avago Technologies ADNS-7530 laser mouse sensor, an 16-pin integrated molded lead-frame staggered dual inline package (DIP), is based on LaserStream^{TM} Technology, which measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the direction and magnitude of movement. Its high performance, low power architecture is capable of sensing high-speed mouse motion while prolonging battery life, two performance areas essential in demanding wireless applications.

The ADNS-7530 sensor along with the ADNS-6150, ADNS-6160-001 and ADNS-6170-002 lens, form a complete and compact laser mouse tracking system. There are no moving parts, which mean high reliability and less maintenance for the end user. In addition, precision optical alignment is not required, facilitating high volume assembly.

Features

- Complete laser mouse reference design kit
- Windows® 98SE, Windows® 2000, Windows® XP and Windows® Vista
- USB full-speed data transfer rate
- User identity code to avoid conflict with other devices
- High reliability
- New LaserStream^{TM} Technology
- Smooth surface navigation
- Enhanced SmartSpeed self-adjusting frame rate for optimum performance
- High speed motion detection up to 30 ips and 8g
- 400, 800, 1200 and 1600 cpi resolution
- No mechanical moving parts
- A high data rate 2.4GHz RF link
- Self-adjusting power-saving modes for longest battery life
- Laser fault detect circuitry on-chip for Eye Safety Compliance
- Minimal number of passive components.

Optical Mouse Basics

The image-based optical mouse sensor takes snap shots of the surface it is navigating on. It measures changes in position by comparing the sequential images (frames) and mathematically determines the direction and magnitude of movement. The traditional duel-channel optical encoder generates the quadrature Z-wheel movement signals. This design guide illustrates the hardware connection of a laser mouse with standard configuration; as well as the firmware management and the handling of the USB protocols. USB protocol provides a standard way of reporting mouse movement and button presses to the PC. The Windows HID driver interprets the USB data and performs the cursor movements and mouse clicks.

The functional block diagram of the reference design mouse is shown in Figure 1. The optical sensor detects the X and Y movements. A mechanical quadrature encoder provides the Z-wheel movement. Each of the button switches is pulled up normally and provides a Ground when pressed. The TSP61070 boost regulator maintains the 2.7 V operating voltage for the reference design mouse from two regular AAA Alkaline batteries in serial. The controls and data are transmitted through 2.4GHz RF by nRF24L01 transceiver and received by the nRF2401A transceiver at the dongle. The control of the mouse is managed by the MSP430F1222 microcontroller; while the dongle is controlled by Silicon Laboratories C8051F326 USB controller.

Mechanical Z-Wheel

The motion of Z-wheel is detected using the traditional method by decoding the quadrature signal generated by mechanical encoder. The Z-pinwheel is connected to the Z-encoder through its shaft. The rotational movement of the shaft is decoded into on and off levels in a quadrature output pattern. Every change in the Z-encoder outputs represents a count of mouse movement. Comparing the last state of the Z-encoder to the current state derives direction information. As shown in Figure 2, traveling in clockwise direction produces a unique set of state transitions, and traveling in counter clockwise direction produces another set of unique state transitions. In this reference design, only the motion at the Z-wheel is detected using this method.

Mouse Buttons

Mouse buttons are connected as standard switches. These switches are pulled up by the pull up resistors inside the microcontroller. When the user presses a button, the switch will be closed and the pin will be pulled LOW to GND. A LOW state at the pin is interpreted as the button being pressed. A HIGH state is interpreted as the button has been released or the button is not being pressed. Normally the switches are debounced in firmware for 15-20ms. In this reference design there are three switches: left, Z-wheel, and right.
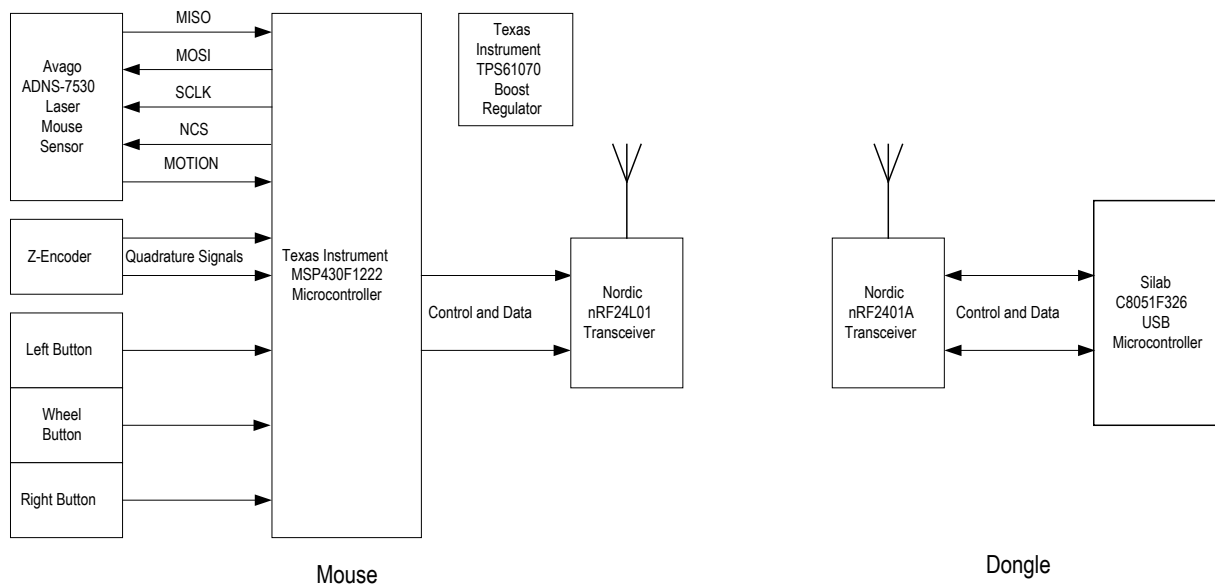

Figure 1. ADNK-7533-TN24 Reference Design Mouse Functional Block Diagram
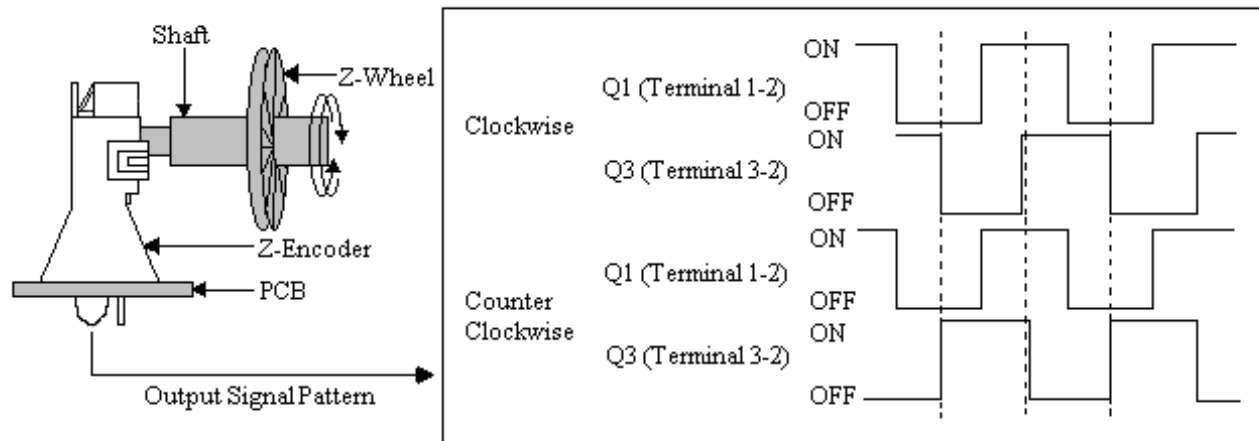
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Figure 2. Mechanical Z-Wheel Output Signal Generation

Avago Technologies ADNS-7530 Low Power Laser Mouse Sensor

Avago Technologies ADNS-7530 laser mouse sensor is the primary navigation engine in this reference design. Based on LaserStream™ Technology, the ADNS-7530 contains an Image Acquisition System (IAS), a Digital Signal Processor (DSP) and a four-wire serial port. Its high-performance, low power architecture is capable of sensing high-speed mouse motion while prolonging battery life, two performance areas essential in demanding wireless applications. The MSP430F1222 microcontroller periodically reads the ADNS-7530's Delta_X_L, Delta_Y_L, Delta_XY_H registers to obtain any horizontal and vertical motion information happening as a result of the mouse being moved. The output of the ADNS-7530 laser mouse optical sensor is four-wire serial port.

This motion information will be reported to the PC through the 2.4 GHz RF and USB protocols to update the position of the cursor. The advantage of using ADNS-7530 laser mouse sensor includes efficient power management, best tracking accuracy and flexibility of programming the optical sensor via the SPI port.

Besides, ADNS-7530 laser mouse sensor performs excellent tracking on difficult surfaces which conventional LED-based technology is unable to track such as glossy and smooth surfaces. In addition, the self-adjusting power-saving modes feature make the ADNS-7530 laser mouse sensor the choice of wireless mouse design for longest battery life.

Features

- Low power architecture
- New LaserStream™ technology
- Self-adjusting power-saving modes for longest battery life
- High speed motion detection up to 30ips and 8g
- Enhanced SmartSpeed self-adjusting frame rate for
- Optimum performance
- Motion detect pin output
- Internal oscillator – no clock input needed
- Selectable 400, 800, 1200 and 1600 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

To learn more about sensor's technical information, please visit the Avago Technologies web site at http://www.avagotech.com.

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Texas Instrument MSP430F1222 Microcontroller

The Texas Instruments MSP430 family of ultra-low power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that attribute to maximum code efficiency. The Digitally Controlled Oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 µsec.

The specific device used in this reference design is the MSP430F1222 with 28 pin to accommodate ample amount of I/O. It is an ultra-low power mixed-signal microcontrollers with a built-in 16-bit timer, 10-bit A/D converter with integrated reference and Data Transfer Controller (DTC), and 14 (20 pin package) or 22 (28 pin package) general purpose I/O pins. The MSP430x12x2 series microcontrollers have built-in communication capability using asynchronous (UART) and synchronous (SPI) protocols. The architecture, combined with five low power modes is optimized to achieve extended battery life on wireless application.

Features

- Low Supply Voltage Range 1.8 V to 3.6 V
- Ultralow-Power Consumption:
  - Active Mode: 200 µA at 1 MHz, 2.2 V
  - Standby Mode: 0.7 µA
  - Off Mode (RAM Retention): 0.1 µA
- Five Power Saving Modes
- Wake-Up From Standby Mode in less than 6 µs
- 16-Bit RISC Architecture, 125 ns Instruction Cycle
- Time
- Basic Clock Module Configurations:
  - Various Internal Resistors
  - Single External Resistor
  - 32-kHz Crystal
  - High Frequency Crystal
  - Resonator
  - External Clock Source
- 16-Bit Timer_A With Three Capture/Compare
- Registers
- 10-Bit, 200-ksps A/D Converter With Internal
- Reference, Sample-and-Hold, Autoscan, and Data Transfer Controller
- Serial Communication Interface (USART0) With Software-Selectable Asynchronous UART or
- Synchronous SPI Serial Onboard Programming, No External Programming Voltage Needed Programmable Code Protection by Security Fuse
- Supply Voltage Brownout Protection
- 4KB + 256B Flash Memory 256B RAM
- Available in 28-Pin Plastic SOWB, 28-Pin Plastic TSSOP, and 32-Pin QFN Packages

For Complete Module Descriptions, See the TI MSP430x1xx Family User's Guide, Literature Number SLAU049

Silab C8051F326 USB Controller

The Silab C8051F326 devices are fully integrated mixed-signal System-on-a-Chip MCUs. The Flash memory can be reprogrammed in-circuit, providing non-volatile data storage, and also allowing field upgrades of the 8051 firmware. User software has complete control of all peripherals, and may individually shut down any or all peripherals for power savings. Each device is specified for 2.7-to-3.6 V operation over the industrial temperature range (–40 to +85 °C). (Note that 3.0-to-3.6 V is required for USB communication.) The Port I/O and /RST pins are tolerant of input signals up to 5 V.

Features

- USB Function Controller
  - USB specification 2.0 compliant
  - Full speed (12 Mbps) or low speed (1.5 Mbps) operation
  - Integrated clock recovery; no external crystal required for full speed or low speed
  - Supports eight flexible endpoints
  - 256 Byte USB buffer memory
  - Integrated transceiver; no external resistors required
- High Speed 8051 µC Core
  - Pipelined instruction architecture; executes 70% of instructions in 1 or 2 system clocks
  - Up to 25 MIPS throughput with 25 MHz clock
  - Expanded interrupt handler
- Memory
  - 1536 bytes internal RAM (1k + 256 + 256 USB FIFO)
  - 16 kB Flash; In-system programmable in 512-byte sectors
- Digital Peripherals
  - 15 Port I/O; All 5 V tolerant with high sink current
  - Enhanced UART
  - Two general purpose 16-bit timers
- Clock Sources
  - Internal Oscillator: 0.25% accuracy with clock recovery enabled. Supports all USB and UART modes
  - External oscillator: Crystal, RC, C, or Clock (1 or 2 pin modes)
  - Switching between clock sources on-the-fly; useful in power saving strategies
- RoHS Compliant Packages
  - 32-pin LQFP (C8051F320)
  - 28-pin QFN (C8051F321)
- Packages
  - 28-pin QFN
  - Temperature Range: –40 to +85 °C

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Nordic Semiconductor nRF24L01 2.4GHz and nRF2401A 2.4GHz Transceivers

The Nordic nRF2402 and nRF2401A are the low-power transceivers for the world wide 2.4 - 2.5 GHz ISM band. The entire transceiver including all inductors and filters are integrated in each single chip respectively which gives the lowest cost solution to the end user. All configurations of the nRF24L01 and nRF2401A transceivers are done via a standard serial interface. The nRF devices include the ShockBurst™ engine which allow for high datarates on air using low datarates between the microcontroller and the nRF device, it will also automatically validate the packets address and CRC, further reducing the microcontrollers processing tasks.

Features for nRF24L01 2.4GHz Transceiver

- 2.4GHz operation
- 80 channels
- 1.9-3.6V voltage supply
- 2Mbit/s data rate
- 0dBm output power
- GFSK modulation
- Efficient output spectrum
- Channel switching time 130µ
- On chip mirror image cancellation
- -40°C to +85°C operation
- Embedded link layer in HW
- Auto acknowledgement
- Auto re-transmission
- Packet identity
- Packet error counter
- MultiCeiver™ - 6 data pipes
- 40-bit address support
- Data validity detection: 16bit CRC
- Separate 32byte RX and TX FIFO's

Features for nRF2401A 2.4GHz Transceiver

- True single chip GFSK transceiver in a small 24-pin package (QFN24 5x5mm)
- Data rate 0 to 1Mbps
- Only 2 external components
- Multi channel operation
- 125 channels
- Channel switching time <200ms.
- Support frequency hopping
- Data slicer / clock recovery of data
- Address and CRC computation
- DuoCeiver™ for simultaneous dual receiver topology
- ShockBurst™ mode for ultra-low power operation and relaxed MCU performance
- Power supply range: 1.9 to 3.6 V
- Low supply current (TX), typical 10.5mA peak @ -5dBm output power
- Low supply current (RX), typical 18mA peak in receive mode
- 100 % RF tested
- No need for external SAW filter

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Wireless RF Technology

This reference design uses two-way communication method through a duo transceiver solution. The nRF24L01 transceiver resides on the mouse PCB and consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator and a modulator. The output power and channel are programmed through SPI. The Chip Select (CS) pin is used to enable the nRF24L01 when the microcontroller is ready to pass the motion or button switch data. Once the data has been loaded into its input buffer, the nRF24L01 manages the transmission; after which it will return to the power down mode to conserve battery power. Typical power consumption is 10 mA at -5 dBm of output power. For more details on the Nordic 2.4GHz RF technology, please read Nordic's application notes nAN400-07 on nRF^{TM} Radio protocol guidelines.

The nRF240x has two transmission modes:

- ShockBurst^{TM}
- Direct Mode

In this reference design, ShockBurst™ protocol is used. It utilizes the on-chip FIFO to accept SPI data at the microcontroller's operating rate but transmits them at rates up to 1 Mbps. The short transmission time translates to low power consumption. For detailed description of the ShockBurst™ technology please refer to Nordic's white paper on nRF240x ShockBurst™ Technology.

High-frequency PCB layout:

A well-designed PCB is necessary to achieve good RF performance. A fully qualified RF layout for the nRF24L01 and its surrounding components, including matching networks for the antenna can be downloaded from: www.nordicsemi.no.

A PCB with a minimum of two layers including a ground plane is recommended for optimum performance. The nRF24L01 DC supply should be well filtered and decoupled as close as possible to the V_{dd} pins with high performance RF capacitors. Specifically a high-grade SMD tantalum capacitor (e.g. 3.3 μF) should be used in parallel with the smaller-value high-frequency bypassing capacitors. The nRF24L01 should have its own branch of well-filtered supply voltage, routed separately from the supply voltage for the digital circuitry. Full swing digital signals should not be routed close to the crystal or the power supply lines.

The receiver is a design from Nordic that is ready to use in any wireless mouse/keyboard application based on the nRF2401A transceiver. Please read Nordic's application note nAN24-04 to learn more about the "Universal low cost USB DuoCeiver™ using nRF2401™".

Hardware Implementation

This reference design uses only 2 printed circuit boards (PCB), i.e one for the main board and the other for the dongle. The MSP430F1222 microcontroller and the Nordic nRF24L01 2.4 GHz transceiver with its associated circuit including the antenna reside on the main board. The Nordic nRF2401A and the Silicon Laboratories C8051F326 USB controller reside on the dongle PCB.

Serial Peripheral Interface (SPI)

The MSP430F1222 provides a dedicated hardware-based Serial Peripheral Interface (SPI). The three-wire interface supports byte serial communication in either Master or Slave mode. In this reference design the MSP430F1222 always acts as the master and initiates all SPI communications with external SPI device(s), in this case the ADNS-7530 and the nRF24L01.

Some details on ADNK-7533-TN24

The ADNK-7533-TN24 reference design mouse unit allows users to evaluate the performance of the Optical Tracking Engine over a USB connection, using a Silab USB Controller. This kit also enables users to understand the recommended mechanical assembly. (See Appendix C, D, and E)

System Requirements

PCs using Windows® 95, Windows® 98, Windows® NT, Windows® 2000, Window® XP, Window® Vista with standard 3-button USB mouse driver loaded.
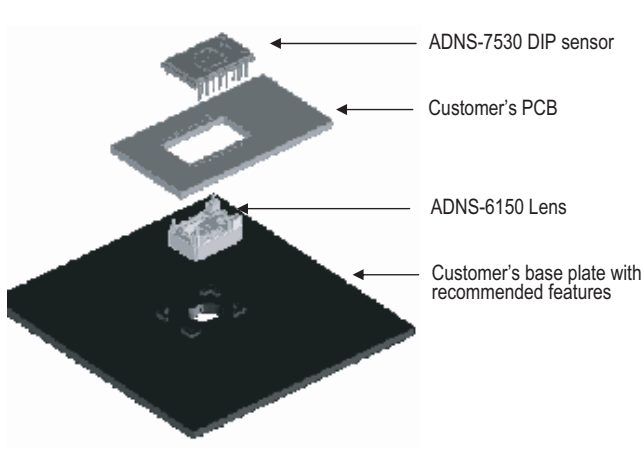
Functionality

3-button, scroll wheel USB-mouse.
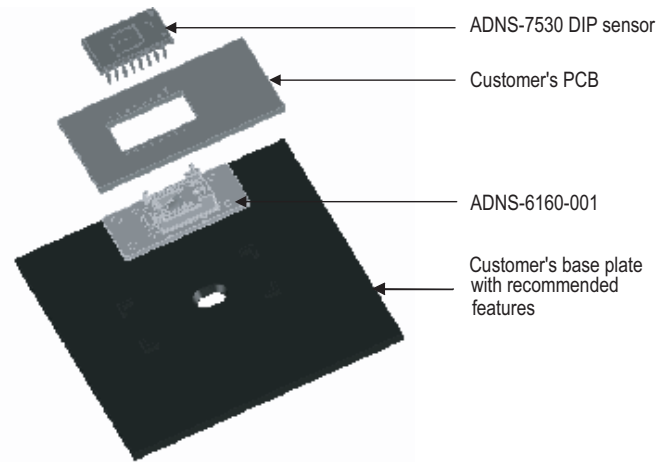
USB Operating Mode

Hot pluggable with USB port. The PC does not need to be powered off when plugging or unplugging the evaluation mouse
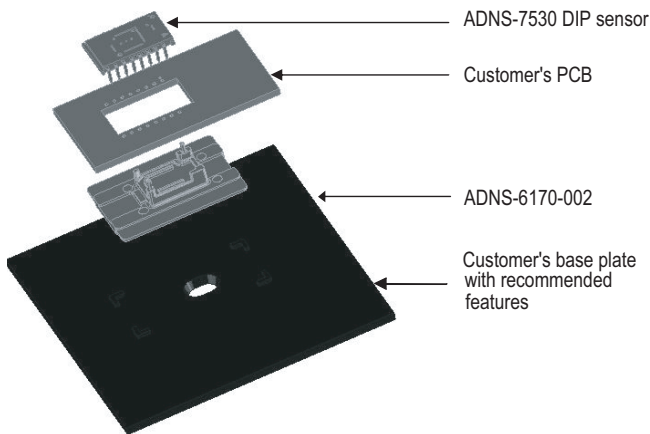
To Disassemble the ADNK-7533-TN24 Unit

The ADNK-7533-TN24 comprises of the plastic mouse casing, printed circuit board (PCB), lens, buttons, and batteries (See Figure 4). Unscrewing the one screw located at the base of the unit can open the ADNK- 7533-TN24 mouse unit. Lifting and pulling the PCB out of the base plate can further disassemble the mouse unit.

ADNS-7530 DIP sensor

Customer's PCB

ADNS-6150 Lens

Customer's base plate with recommended features

Figure 3a. Exploded view drawing of optical tracking engine with ADNS-7530 laser mouse sensor with the ADNS-6150 lens, PCB and base plate

ADNS-7530 DIP sensor

Customer's PCB

ADNS-6160-001

Customer's base plate with recommended features

Figure 3b. Exploded view drawing of the ADNS-7530 laser mouse sensor with the ADNS-6160-001 lens, PCB and base plate

ADNS-7530 DIP sensor

Customer's PCB

ADNS-6170-002

Customer's base plate with recommended features

Figure 3c. Exploded view drawing of the ADNS-7530 laser mouse sensor with the ADNS-6170-002 lens, PCB and base plate

Sensor

Lens

Navigation surface

Lens to surface 2.40
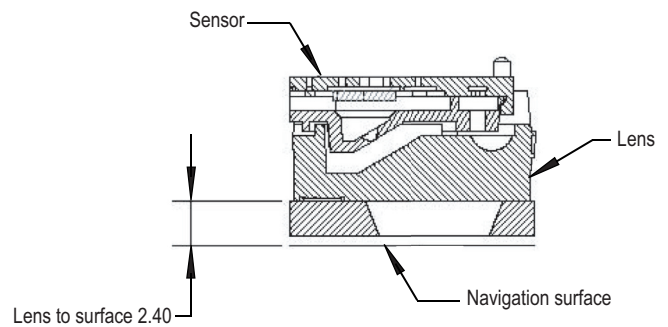
Figure 4. Distance from lens reference plane to surface

While reassembling the components, please make sure that the Z height (Distance from lens reference plane to surface) is valid. Refer to Figure 4.

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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.

- Provides sufficient ESD creepage/clearance distance to avoid discharge up to 15kV when assembled into a mouse according to usage instructions above.

- For eye safety consideration, please refer to the document, Eye Safety Calculation AN5361 available on the Avago Technologies web site.

Eye Safety

The ADNS-7530 and the associated components in the schematic of Appendix A 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" of ADNS-7530 datasheet. 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 so that the ADNS-6150, ADNS-6160-001 or ADNS-6170-002 lens permeates output beam power that is as close as possible to 506W without exceeding it. The system comprised of the ADNS-7530 and ADNS-6150, ADNS-6160-001 or ADNS-6170-002 lens, 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 circuit in Appendix A. For more information, please refer to Eye Safety Application Note AN5361.

LASER Power Adjustment Procedure

1. The ambient temperature should be 25 °C +/- 5 °C.

2. Set V_{DD3} to its permanent value.

3. Set the Range bits (bit 7 and 6 of register 0x1a) to b'01.

4. Set the Range_C1 and Range_C0 complement bits (bit 7 and 6 of register 0x1f) to b'10.

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. Set the laser current to the minimum value by writing 0x00 to register 0x1c, and the complementary value 0xFF to register 0x1d.

7. Program registers 0x1c and 0x1d with increasing values to achieve an output power of not more than 506 μW to meet class 1 Eye Safety over temperature. If this power is obtained, the calibration is complete, skip to step 12.

8. 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.

9. Set the Range and Range_C bits in registers 0x1a and 0x1f, respectively, to choose to the higher laser current range.

10. Program registers 0x1c and 0x1d with increasing values to achieve an output power of not more than 506 μW to meet class 1 Eye Safety over temperature.

11. 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-7530 is reset.

12. 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.

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 V_{DD3} value is no greater than 300mV above its value at the time of adjustment.

4. No allowance for optical power meter accuracy is assumed.

Below is the summary of the components contained in the ADNK-7533-TN24 Designer's Kit.

Laser Mouse Sensor and Lens

Technical information on the sensor can be obtained from the ADNS-7530 Data Sheet. For technical details on the lenses used to complement the ADNS-7530 sensor, kindly refer to the ADNS-6150, ADNS-6160-001 and ADNS-6170-002 lens data sheets. Additional application notes regarding Eye Safety Requirements are also available at Avago Technologies website.

RF Transceivers

Technical information on the Nordic Semiconductor nRF24L01 and nRF2401A are detailed in their respective datasheets. The RF design considerations are available in the application notes that can be found in Nordic's website.

Microcontrollers

Technical information on the TI MSP430F1222 microcontroller is available in the TI Data Sheet. Please contact your local TI office for the MSP430 development tools. These tools allow designers to make changes and recompile the source code, perform In-Circuit Emulation and debug new code for added features. Programming support and programmer adaptors for the MSP430 can be found through TI or through other 3rd party programming tool companies.

For further information on this product, please contact Texas Instrument.

Silab provides extensive development tools for the C8051F326 USB controller used in the receiver dongle. For further information on this product, please contact Silicon Laboratories.

Base Plate Feature – IGES File

The IGES file on the CD-ROM provides recommended base plate molding features to ensure optical alignment. This includes PCB assembly diagrams like solder fixture in assembly and exploded view, as well as solder plate. See Appendix D for details.

Overall circuit

The schematics of the overall circuit for mouse and USB dongle are shown in Appendix A of this document. Appendix B lists the bill of materials.

Reference Design Documentation – Gerber Files

The Gerber File presents detailed schematics used in ADNK-7533-TN24 in PCB layout form. See Appendix C for more details.

Firmware Implementation

The firmware for this reference design is written in the C language. The following files are required to compile the mouse firmware.

MSP430_AVAGO_ADNS-7530.c – main mouse configuration codes resides here.

CRC-8.c - Routines for CRC-8 generation

wm430_buttons.c - used to store button state data for tx message

wm430_system.c – General system configuration including but not limited to IOs, timers and other system related functions. The main program loop resides here.

wm430_transmitter.c - Implements the RF transmitter protocol

wm430_wheel.c - Implements the logic to detect scroll wheel movement

_FSKDATAPLUSENCODING - used to enable MSP430 to shift data out via FSK scheme by toggling the RF_DATA line at specific bit periods

The user should insert the receiver dongle into an available USB port at the computer. Install two AA alkaline batteries into the battery compartment. Pay special attention to the polarities of the two batteries. The reference design mouse is designed to work with two AA batteries in parallel or just one AA battery. The USB receiver dongle will be detected by the PC as HID and any button press and mouse motion will make up the RF connection between the receiver and mouse. When the mouse is properly "connected" to the dongle, every time it receives a transmission from the mouse the green LED lights up.
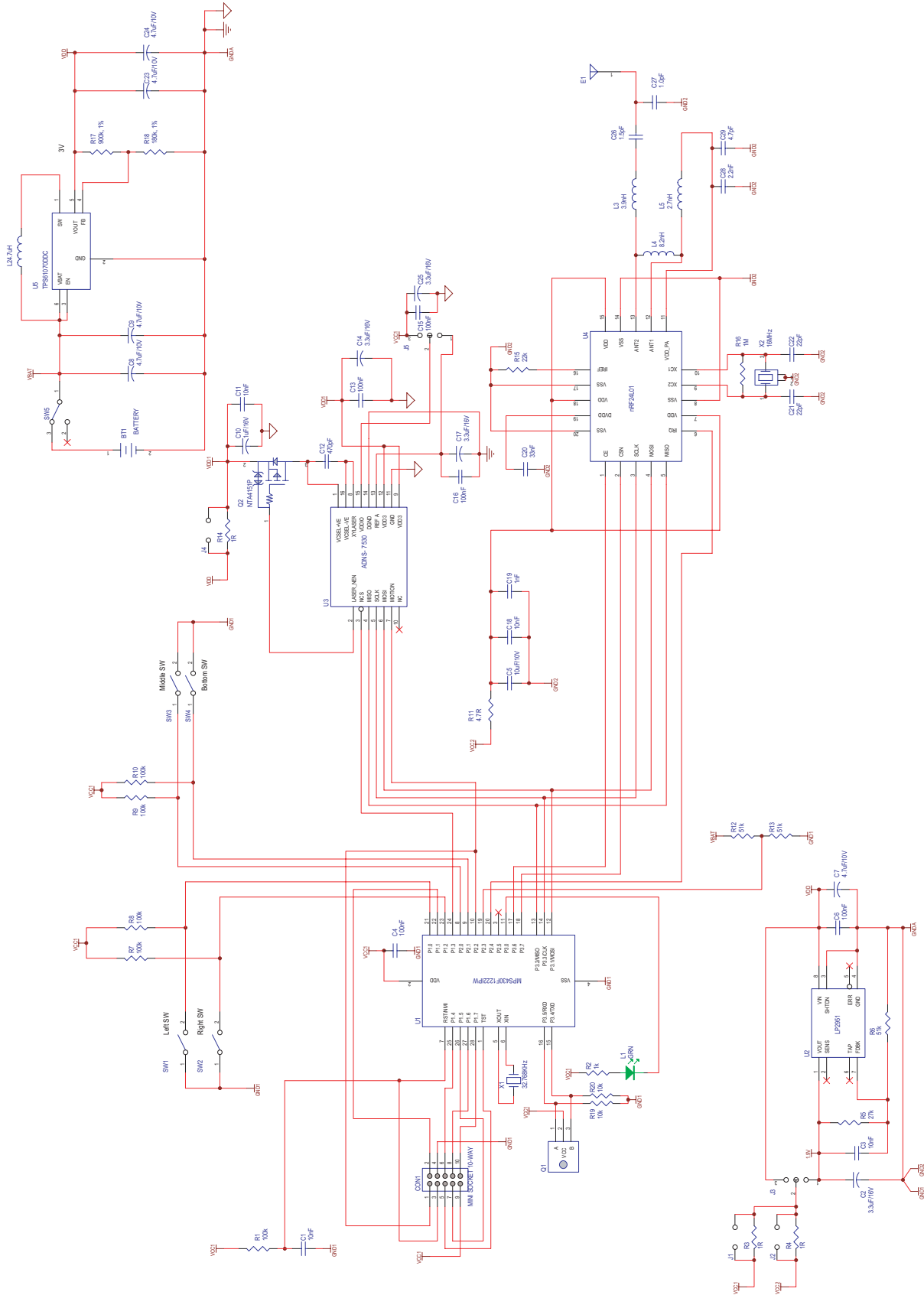
Appendix A: Schematic Design of Overall Circuit

Figure A1. Circuit diagram of MSP430F1222 microcontroller and nRF24L01 transceiver in ADNK-7533-TN24 designer's kit wireless laser mouse
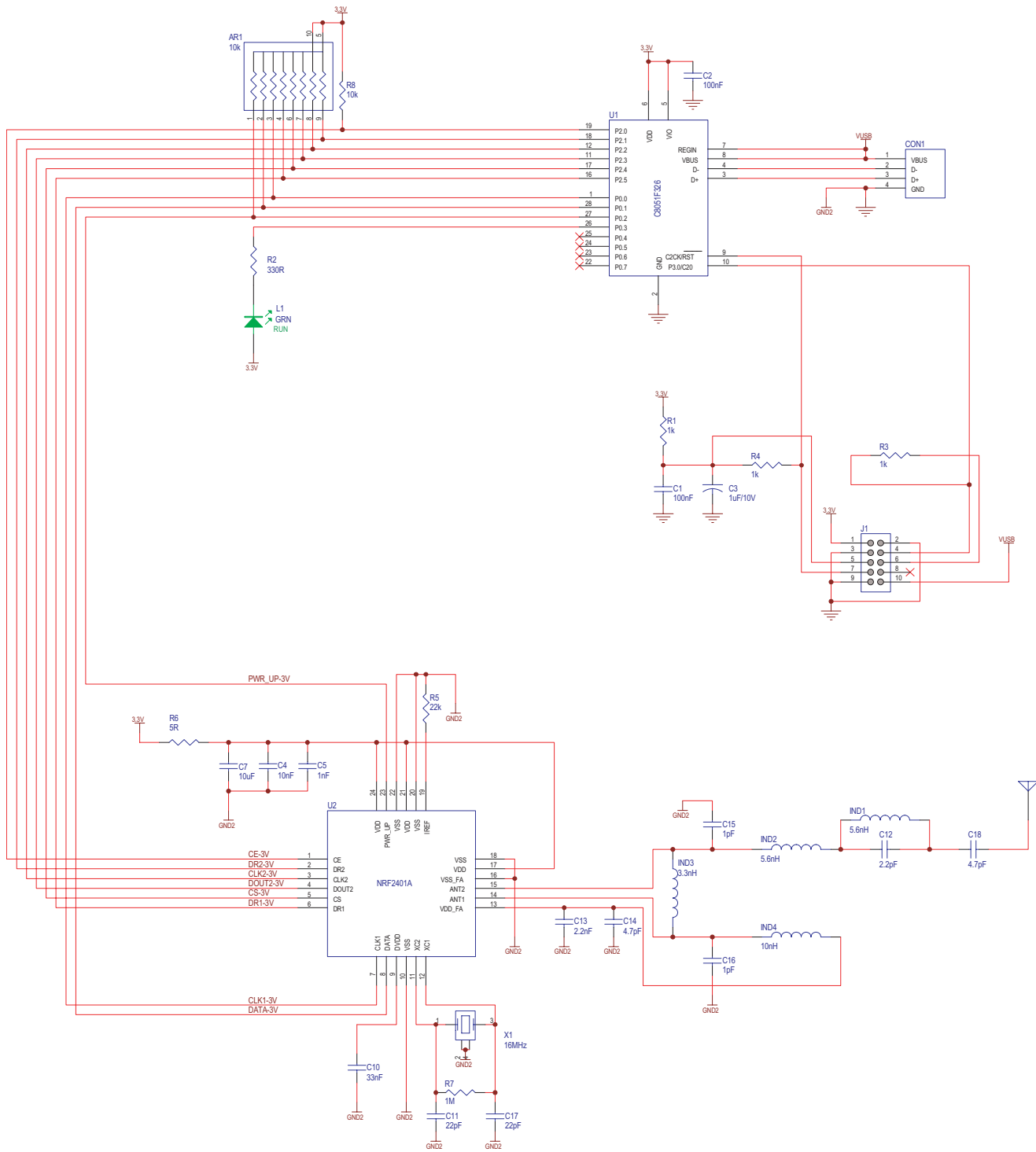
Figure A2. Circuit diagram of nRF2401A transceiver in ADNK-7533-TN24 designer's kit wireless laser mouse

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Appendix B: Bill of Materials for ADNK-7533-TN24 Wireless Laser Mouse Designer's Kit

Table B3. Bill of materials for ADNK-7533-TN24 wireless laser mouse designer's kit main board

No	Description	Color / Value	Qty	Reference
01.	Resistor	1R 1%	3	R3.R4.R14.
02.	Resistor	4R7 1%	1	R11.
03.	Resistor	1K 1%	1	R2.
04.	Resistor	10K 1%	2	R19.R20.
05.	Resistor	22K 1%.	1	R15.
06.	Resistor	27K 1%	1	R5.
07.	Resistor	51K 1%	3	R6.R12.R13.
08.	Resistor	100K 1%	5	R1.R7.R8.R9.R10.
09.	Resistor	180K 1%	1	R18.
10.	Resistor	910K 1%	1	R17.
11.	Resistor	1M 1%	1	R16.
12.	Capacitor Ceramic	1pF,50V	1	C27.
13.	Capacitor Ceramic	1.5pF,50V	1	C26.
14.	Capacitor Ceramic	4.7pF,50V	1	C29.
15.	Capacitor Ceramic	22pF,50V	2	C21.C22.
16.	Capacitor Ceramic	470pF,50V	1	C12.
17.	Capacitor Ceramic	1nF,50V	1	C19.
18.	Capacitor Ceramic	2.2nF,50V	1	C28.
19.	Capacitor Ceramic	10nF,25V	4	C1.C3.C11.C18.
20.	Capacitor Ceramic	33nF,50V	1	C20.
21.	Capacitor Ceramic	100nF,16V	5	C4.C6.C13.C15.C16.
22.	Capacitor Ceramic	1uF,16V	1	C10.
23.	Capacitor Tantalum	3.3uF,16V	4	C2.C14.C17.C25.
24.	Capacitor Ceramic	4.7uF,16V	5	C7.C8.C9.C23.C24.
25.	Capacitor Ceramic	10uF,10V	1	C5.
26.	LED	Green	1	L1.
27.	Inductor	2.7nH	1	L5.
28.	Inductor	3.9nH	1	L3.
29.	Inductor	4.7uH	1	L2.
30.	Inductor	8.2nH	1	L4.
31.	Connector - Socket DUAL Entry	10way	1	CON1.
32.	Crystal	16MHz	1	X2.
33.	Crystal	32.768KHz	1	X1.
34.	IC SMD	LP2951ACM	1	U2.
35.	Miccontroller	TI MSP430F1222IPW	1	U1.
36.	Regulator	TPS61070DDCR	1	U5.
37.	IC Nordic	NRF24L01	1	U4.
38.	IC Mosfet	NTA4151PT1G	1	Q2.
39.	Battery Clip (Mini Mouse Spring)	-	2	B+. B-
40.	Switch - Push Button	SPN0 - SMD	1	SW4.
No	**Description**	**Color / Value**	**Qty**	**Reference**

No	Description	Color / Value	Qty	Reference
41.	Latch Switch	3way	1	SW5.
42.	Switch - Small Casing Push Button	Black	3	SW1.SW2.SW3.
43.	Z-Encoder	Red	1	Q1.
44.	Laser Sensor Device	ADNS-7530	1	U3.
45.	Lens - ADNS-6150	-	1	-
46.	Small Casing	-	1	-
47.	Small Casing Roller	-	1	-
48.	Small Casing Screw	-	3	-
49.	Small Casing Mouse Foot	-	-	-
50.	PCB Model : Array 2752-M-01-B	-	1	-

Table B4. Bill of materials for ADNK-7533-TN24 wireless laser mouse designer's kit USB DuoCeiver^{TM} dongle

No	Description	Color / Value	Qty	Reference
01.	Resistor	4R7 5%	1	R6.
02.	Resistor	330R 5%	1	R2.
03.	Resistor	1K 1%	3	R1.R3.R4.
04.	Resistor	10K 1%	1	R8.
05.	Resistor	22K 1%	1	R5.
06.	Resistor	1M 1%	1	R7.
07.	Resistor Array	10K 1%	1	AR1.
08.	Capacitor Ceramic	1pF,50V	2	C15.C16.
09.	Capacitor Ceramic	1.5pF,50V	1	C12.
10.	Capacitor Ceramic	4.7pF,50V	2	C14.C18.
11.	Capacitor Ceramic	22pF,50V	2	C11.C17.
12.	Capacitor Ceramic	1nF,50V	1	C5.
13.	Capacitor Ceramic	2.2nF,50V	1	C13.
14.	Capacitor Ceramic	10nF,25V	1	C4.
15.	Capacitor Ceramic	33nF,50V	1	C10.
16.	Capacitor Ceramic	100nF,16V	2	C1.C2.
17.	Capacitor Ceramic	1uF,16V	1	C3.
18.	Capacitor Ceramic	10uF,10V	1	C7.
19.	Inductor	3.3nH	1	IND3.
20.	Inductor	5.6nH	2	IND1.IND2.
21.	Inductor	10nH	1	IND4.
22.	LED	Green	1	L1.
23.	Connector - USB Connector Type-A	4way	1	CON1.
24.	Connector - Socket DUAL Entry	10way	1	J1.
25.	Crystal	16MHz	1	X1.
26.	IC Nordic	NRF2401AG	1	U2.
27.	IC SMD	C8051F326-GM	1	U1.
28.	PCB Model : AFX 2752-M-02-D	-	1	-
29.	Casing - Small Casing Dongle	-	1	-

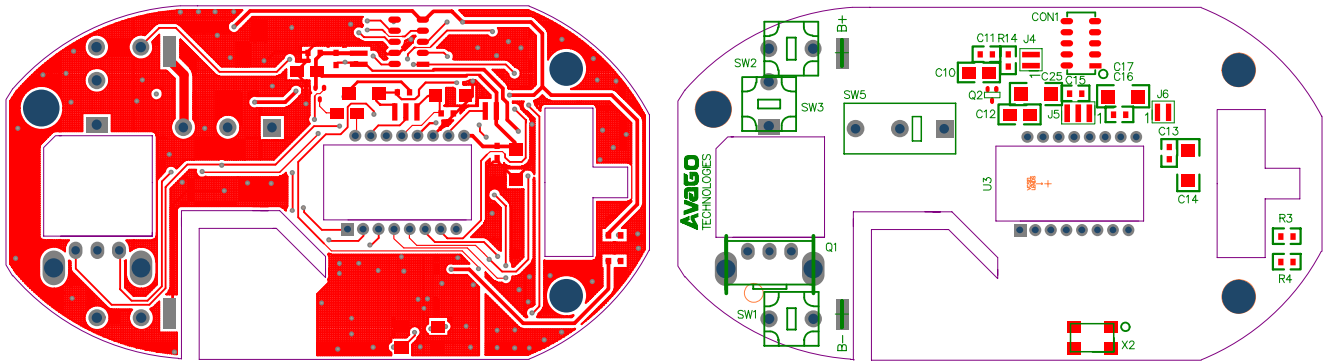## Appendix C: PCB Layout

Figure C1. Top layer PCB layout and assembly drawing of ADNK-7533-TN24 wireless laser mouse designer's kit
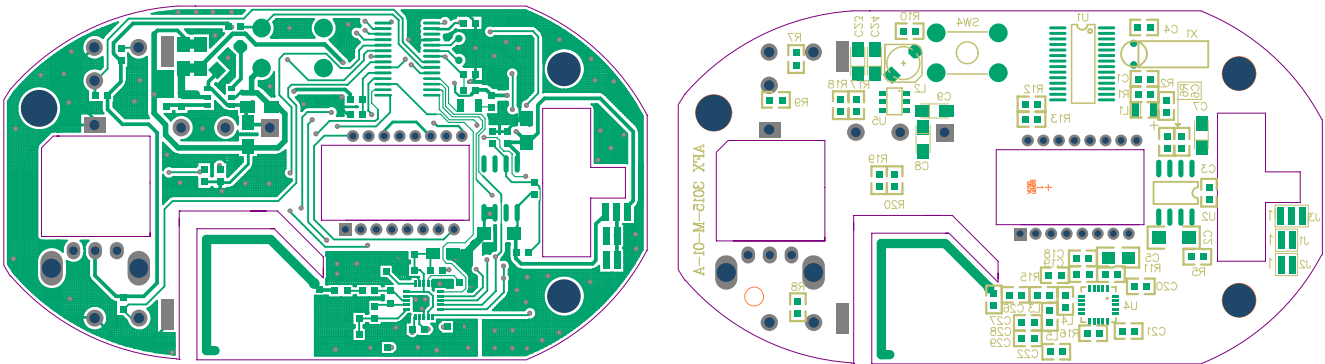

Figure C2. Bottom layer PCB layout and assembly drawing of ADNK-7533-TN24 wireless laser mouse designer's kit
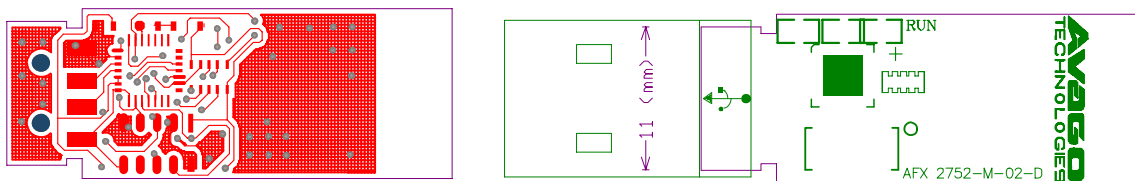

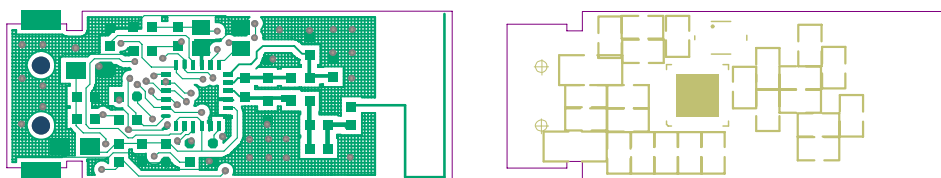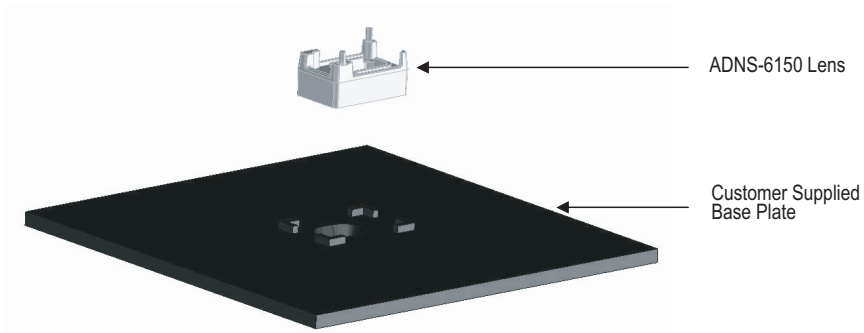**Figure C3. Top layer PCB layout and assembly drawing of ADNK-7533-TN24 wireless laser mouse designer's kit USB DuoCeiver^{TM} dongle**

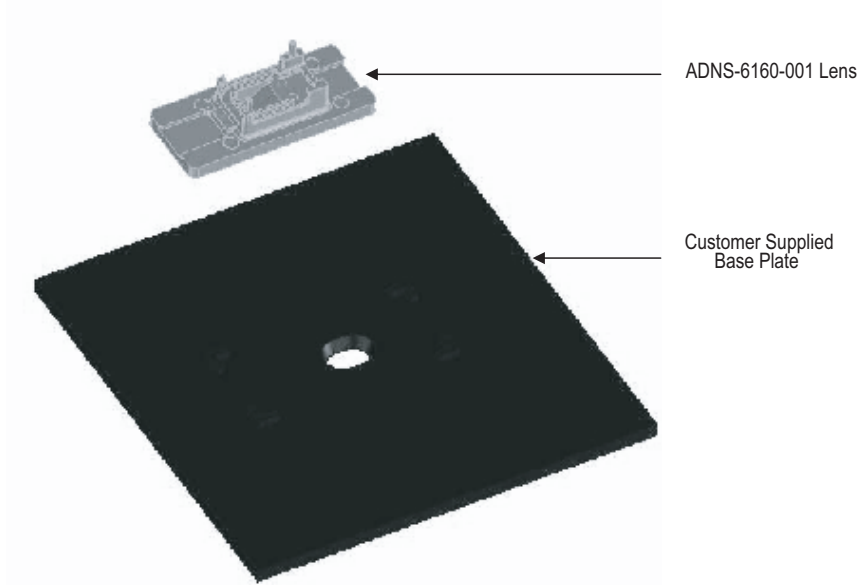**Figure C4. Bottom layer PCB layout and assembly drawing of ADNK-7533-TN24 wireless laser mouse designer's kit USB DuoCeiver^{TM} dongle**

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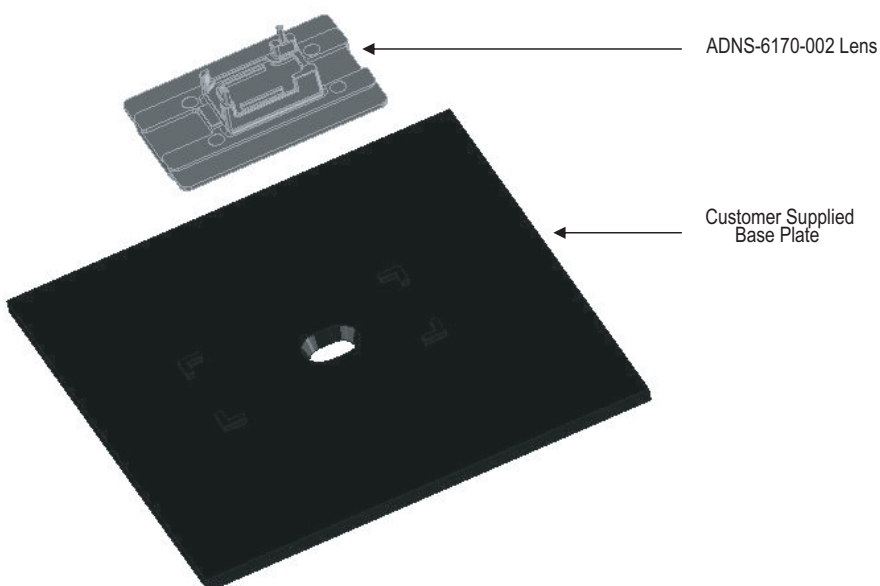## Appendix D: Base Plate Feature

ADNS-6150 Lens

Customer Supplied Base Plate

Figure D1. Illustration of base plate mounting features for ADNS-6150 laser mouse SFF lens

ADNS-6160-001 Lens

Customer Supplied Base Plate

Figure D2. Illustration of base plate mounting features for ADNS-6160-001 laser mouse SFF trim lens

ADNS-6170-002 Lens

Customer Supplied Base Plate

Figure D3. Illustration of base plate mounting features for ADNS-6170-002 laser mouse wide trim lens

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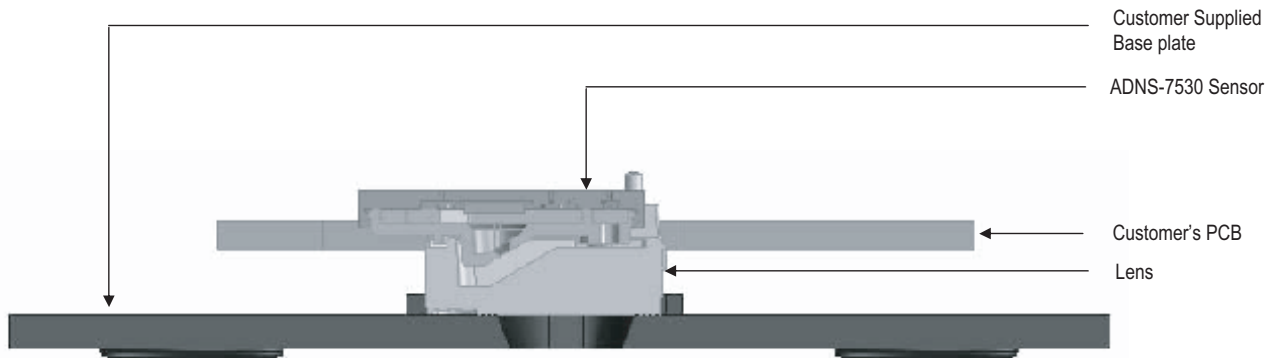## Appendix E: Sectional view of PCB assembly

Customer Supplied
Base plate

ADNS-7530 Sensor

Customer's PCB

Lens

Figure E1. Sectional view of PCB assembly highlighting all optical mouse components (laser mouse sensor, ADNS-6150 lens, PCB and base plate)
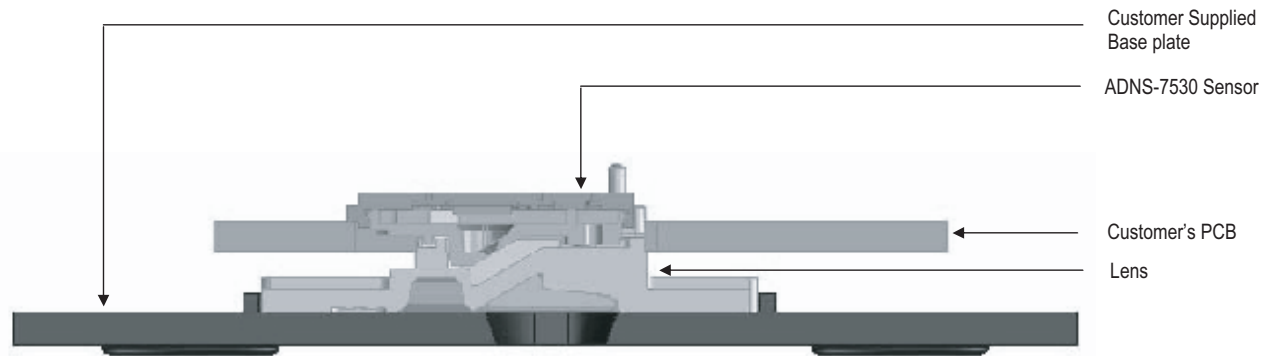
Customer Supplied
Base plate

ADNS-7530 Sensor

Customer's PCB

Lens

Figure E2. Sectional view of PCB assembly highlighting all optical mouse components (laser mouse sensor, ADNS-6160-001 lens, PCB and base plate)
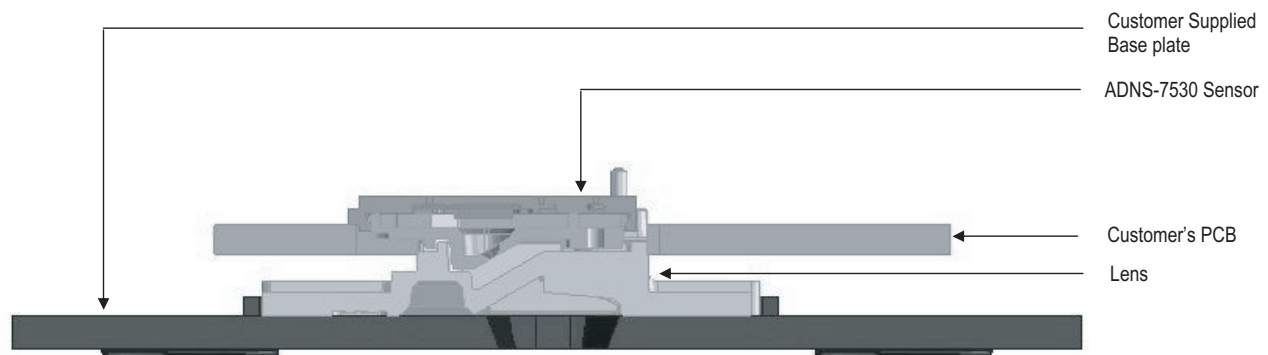
Customer Supplied
Base plate

ADNS-7530 Sensor

Customer's PCB

Lens

Figure E3. Sectional view of PCB assembly highlighting all optical mouse components (laser mouse sensor, ADNS-6170-002 lens, PCB and base plate)

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Appendix F: Kit Components

Part Number	Description	Name	Quantity
ADNK-7533-TN24 Mouse Set	a. Wireless Laser Mouse b. USB Dongle	Reference Design Mouse Set	1
ADNS-7530	Laser Mouse Sensor	Sensor	5
ADNS-6150	Laser Mouse Round Lens Plate	Lens	5
ADNS-6160-001	Laser Mouse Trim Lens Plate	Lens	5
ADNS-6170-002	Laser Mouse Wide Trim Lens Plate	Lens	5
ADNK-7533-TN24 CD-ROM	Includes Documentation and Support Files for ADNK-7533-TN24 Documentations a. ADNS-7530 Laser Mouse Sensor Data Sheet b. ADNS-6150 Small Form Factor Lens Data Sheet c. ADNS-6160-001 Trim Lens Data Sheet d. ADNS-6170-002 Wide Trim Lens Data Sheet e. ADNK-7533-TN24 Laser Mouse Designer's Kit Design Guide f. Avago Technologies Laser Mouse Eye Safety Calculation Application Note AN5361 g. Nordic Semiconductor nRF24L01 RF Transceiver Datasheet h. Nordic Semiconductor nRF2401A RF Transceiver Datasheet i. Nordic Semiconductor nRFTM Radio protocol guidelines Application Notes nAN400-07 j. Nordic Semiconductor nRF240x ShockBurst™ Technology White Paper k. Nordic Semiconductor Universal low cost USB DuoCeiver™ using nRF2401™Application Note AN24-04 l. Texas Instrument MSP430F1222 Microcontroller Datasheet m. Silicon Laboratories C8051F326/7 USB Microcontroller Data Sheet Hardware Support Files a. ADNK-7533-TN24 BOM List b. ADNK-7533-TN24 Schematic c. ADNK-7533-TN24 Gerber File. d. 3D Model IGES Files Software Support Files a. Mouse Firmware - Texas Instrument MSP430F1222 Microcontroller b. USB Dongle Firmware – Silicon Laboratories C8051F326 USB microcontroller		1

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