ADNK-3043-BRBT
Bluetooth Optical Mouse Designer's Kit

Design Guide

Introduction

This design guide describes the design of a low power consumption Bluetooth optical mouse using the Avago Technologies ADNS-3040 optical navigation sensor and Broadcom BCM92042MDX-B88 Bluetooth ROM module. The receiver dongle is implemented with a Broadcom BCM2045 Chip. The document starts with the basic operations of a computer mouse peripheral followed by an introduction to the Avago Technologies ADNS-3040 Optical Navigation Sensor and the Broadcom BCM92042MDX-B88 Bluetooth ROM module. The software section of this design guide gives overview about the general architecture of the firmware implemented in the mouse.

All schematic diagrams of the BCM92042MDX-B88 Bluetooth ROM module to the ADNS-3040 optical sensor and buttons of a standard mouse, as well as the receiver dongle, can be found in Appendix A. The ADNS-3040 data sheet is available from the Avago Technologies website at: *http://www.avagotech.com*. The Bluetooth device information is available from the Broadcom website at *www.broadcom.com*. USB documentation can be found at the USB Implementers Forum web site at www.usb.org. For more information regarding Bluetooth, please visit *www.bluetooth.com*

Features

- Complete LED Bluetooth mouse reference design kit
- Windows® 98SE, Windows 2000, and Windows XP compatibility
- USB 2.0 low-speed compliance
- User identity code to avoid conflict with other devices
- High reliability
- Smooth surface navigation
- Enhanced SmartSpeed self-adjusting frame rate for optimum performance
- High speed motion detection up to 20 ips and 8 G
- 800 cpi resolution
- A high data rate 2.4 GHz RF link
- Transmission data rate up to 1 Mbps
- 10 meters communication distance
- Self-adjusting power saving modes for longest battery life
- Minimal number of passive components

Reference Design Overview

The image-based optical mouse sensor takes snapshots 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 dual-channel encoder generates the quadrature Z-wheel movement signals. This design guide illustrates the hardware connection of a LED-based optical mouse with standard configuration; as well as the firmware management and the handling of the USB HID and Bluetooth protocols. USB HID protocol provides a standard way of reporting mouse movement and button presses to the PC. The Windows HID with Bluetooth driver interprets the 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 Y and X movements. The mechanical quadrature encoder provides the Z-wheel movement. Each of the button switches is normally pulled up and provides a Ground when pressed. The reference design mouse is powered up by two regular AA Alkaline batteries in series.

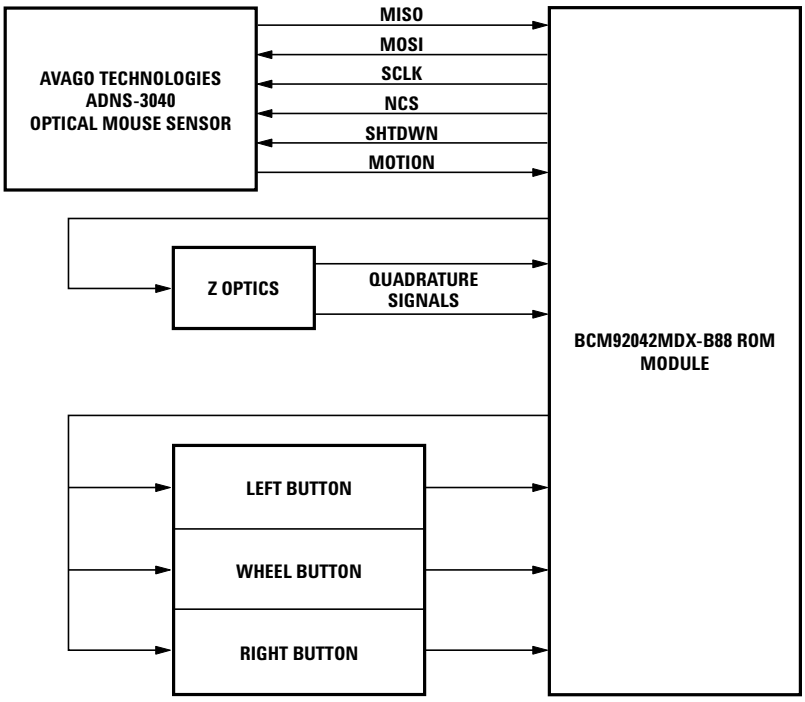


Figure 1. ADNK-3043-BRBT reference design mouse functional block diagram

Theory of Operation

Optical Navigation Technology

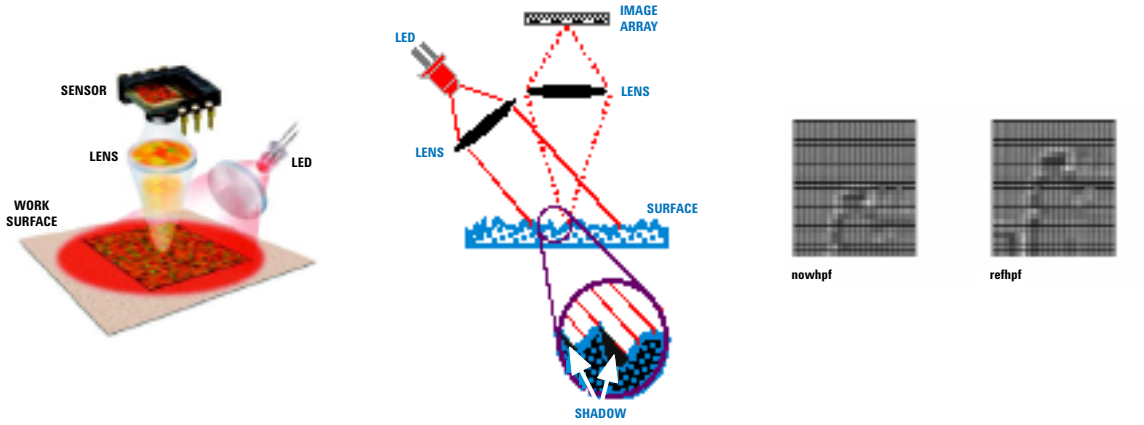


Figure 2. Illustration of optical navigation technology

The heart of the ADNS-3040 navigation sensor is a CMOS image array. An LED and an optical system illuminate the surface that the ADNS-3040 is navigating on. The texture of the surface casts bright and dark spots forming distinct images as the sensor is moved across the surface. A Digital Signal Processing (DSP) engine and its built-in algorithm evaluate these images and determine the magnitude and direction of the movement. The motion data is made available in the delta_Y and delta_X registers for the system controller to retrieve. An extensive power saving topology is implemented within the ADNS-3040 navigation engine. A Motion pin (output) is available to act as the system interrupt. As long as there is no motion the system can remain in Sleep mode allowing maximum battery power saving. Based on the last detected motion the ADNS-3040 navigation engine enters various power saving modes when no new motion occurs. These power saving features make the ADNS-3040 ideally for wireless applications.

Mechanical Z-Wheel

The motion of Z-wheel is detected using the traditional method by decoding the quadrature signal generated by the 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 3, 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.

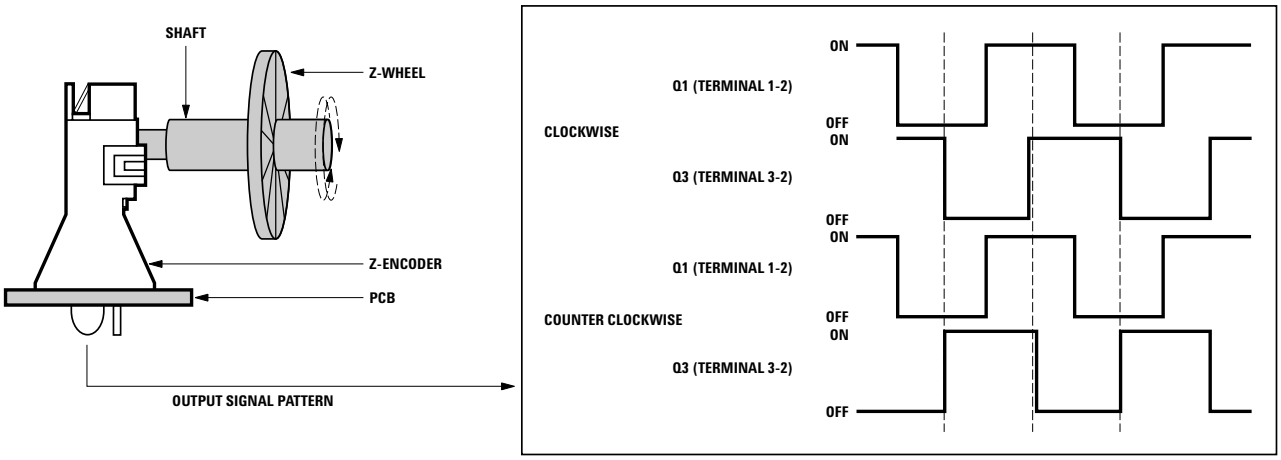


Figure 3. Mechanical Z-wheel output signal generation

Mouse Buttons

Mouse buttons are connected as standard switches to the BCM2042 Key-Scan matrix which is designed to autonomously sample button status with the programmable hardware de-bounce and ghost key/glitch filtering and store them into buffer registers without the need for the host microcontroller to intervene. In this reference design there are three switches: left, middle, and right.

Hardware Implementation

Optical Mouse Sensor

This reference design features the ADNS-3040 optical navigation engine. It contains an Image Acquisition System (IAS), a Digital Signal Processor (DSP), and a three-wire Serial Peripheral Interface consists of the serial clock (SCLK), the master-in/slave-out (MISO) and the master-out/slave-in (MOSI). An addition fourth signal, Motion, is an output intended to act as an interrupt to the microcontroller whenever the ADNS-3040 senses motion. When the mouse is moved, the ADNS-3040 alerts the system controller by activating the Motion signal which triggers an interrupt service routine. At the same time, the ADNS-3040 accumulates the horizontal and vertical displacements in its Delta_Y and Delta_X registers respectively. The ADNS-3040 deactivates the Motion signal as soon as movement stops. The *SmartSpeed* technology automatically optimizes the frame rate by examining the acquired images of the surface. It also manages the integrated LED driver to coordinate with the shutter.

The system controller reads the motion information and reports it to the PC to update the cursor position.

The advantages of using ADNS-3040 optical sensor are the efficient power management, high tracking accuracy, and efficient communications with the optical sensor via the full duplex SPI port.

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

Broadcom BCM92042MDX-B88 ROM Module

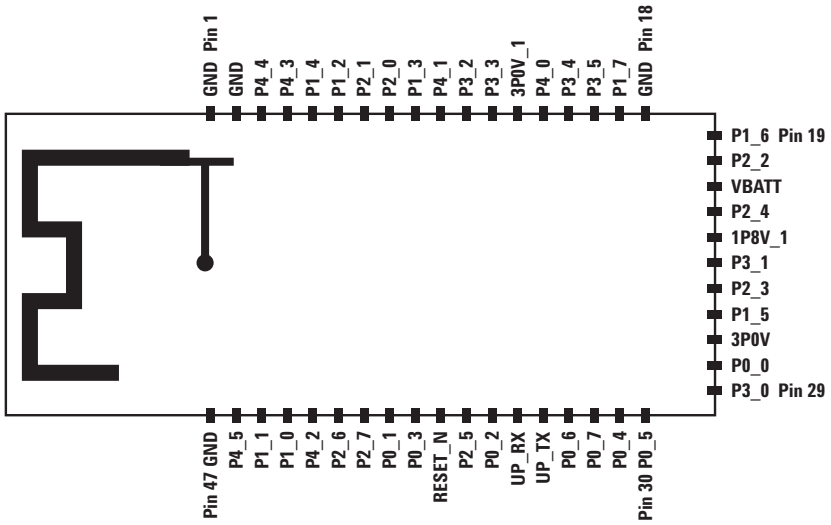
General Description

The Broadcom BCM2042MDXB88 module is a Bluetooth HID Profile 1.0 compliant product based on BCM2042 chip. The module is ideal for applications in wireless input devices including keyboards, mice, joysticks, and game controllers. The module is designed to provide low-power, low-cost, robust communications for applications operating in the globally available 2.4-GHz unlicensed ISM band.

Main Features:

- Class 2 Module
- Integrated switching regulator to support external sensor to reduce external BOM cost. Dual Voltage output 1.8 V and 3.0 V
- Bluetooth HID profile version 1.0 compliant
- Supports Adaptive Frequency Hopping (AFH)
- Excellent receiver sensitivity about -85 dBm
- EEPROM mounted module design
- On-chip support for common keyboard and mouse interfaces eliminates external processor
- Programmable key-scan matrix interface, up to 8x20 key-scanning matrix
- Three-axis quadrature signal decoder for mouse application, SPI interface, A/D input
- On-chip support for Serial Peripheral Interface (master mode only)
- Integrated 8051 microprocessor core
- On-chip software control power management unit

Pin Definition



This is the TOP view of module. No need to mirror the pin out while creating module footprint.
For advanced dimension information, please check with the gerber of BCM92042MDX-B88 board.

Figure 4. Pinouts for BCM92042MDX-B88 module (top view)

Pin for Power Domain	Pin Number	Direction	Note
VBATT	21	In	1.8 V ~ 3.3 V
GND	1, 2, 18, 47	GND	
3 P0V_1	13	Output	3.0 V
3 P0V	27	In	Internal connected to 3 P0V_1
1 P8V_1	23	Output	1.8 V
RESET_N	38	In	External reset input

Please refer to the Broadcom BCM2042 chip datasheet for GPIO pin description.

Hardware Implementation

The standard hardware to implement a Bluetooth optical mouse is shown in Figure 1. Optical mouse detects the Y and X movements while the Z-wheel movement is decoded by the mechanical encoders that output quadrature signals. For each button, there is a switch that has a common side pin connected together with the BCM92042MDX-B88 ROM module.

The function of the BCM92042MDX-B88 ROM Module is to:

- Get the XY displacement from the optical sensor ADNS-3040
- Detect the Z displacement
- Check button status
- Generate BT HID data and send to host
- Perform the overall power management

XY Displacement and Sensor Power Control

The BCM92042MDX-B88 ROM module has an SPI hardware integrated in the BCM2042 chip where four-wire supports both full-duplex mode. The communication between the sensor and the BCM92042MDX-B88 ROM Module is through a serial peripheral interface (SPI) with clock input at the SCLK pin and bi-direction data interface at MISO and MOSI pin.

BCM2042 ROM Module has two optional output ports. The SPI I/O configurations are as below:

	Configuration A	Configuration B
SPI Clock	P4_2	P2_6
MOSI (Master Out Slave In)	P4_3	P2_7
MISO (Master In Slave Out)	P4_4	P2_5
CS (Chip Select)	Any	Any

Configuration B is used in this reference design mouse. P3_0 is used for CS control pin. For detailed description, please refer to the BCM2042 chip datasheet.

Quadrature Interface for Z Axis Control

The mouse signal decoder is designed to automatically sample two quadrature signals commonly generated by mechanical z-wheel encoder.

The decoder has the following features:

- Two sets of pin assignment option for the X, Y, and Z (typical scroll wheel) axis signals:

		Option A	Option B
X axis	X0	P0_2	P4_0
	X1	P0_3	P4_1
Y axis	Y0	P0_4	P4_2
	Y1	P0_5	P4_3
Z axis	Z0	P0_6	P4_4
	Z1	P0_7	P4_5

In this reference design, we use P0_6 and P0_7 as Z axis signal detector pin and P3_3 as common pin.

- Control of up to four external high current GPIOs to power external optical-electronics:
  - 4 HC GPIOs: P3_2, P3_3, P3_4, P3_5 support up to 16 mA
  - Turn-on and turn-off time can be staggered for each HC-GPIO to avoid simultaneous switching of high currents and to avoid having multiple high-current devices on at the same time. Sampling time can be staggered for each axis.
  - Sense of the control signal can be active-high or active-low.
  - Control signal may be configured to be tri-stated for off condition or driven high/low as appropriate.

Button Status Checking:

BCM2042MDX-B88 module supports hardware key-scan interface up to 8 x 20 keys for keyboard application and a few for mouse application. The recommended interface implementation is to use the Port 0 as the common input while Port 1 and Port 2 are used as the scan column output pin. For example:

1. 3 button design : 1 row x 3 column & P0_0 as row, P1_0, P1_1, and P1_2 as column
2. 16 button design : 4 row x 4 column & P0_0, P0_1, P0_2, and P0_3 as rows, P1_0, P1_1, P1_2, and P1_3 as column
   : 1 row x 16 column & P0_0 as row, P1_0-P1_7, and P2_0-P2_7 as column

For more detail information, please refer to the BCM2042 chip datasheet

PCB Layout and Design Guidelines

Special details should be taken into consideration while working on the PCB layout. By following the guidelines below, performance of the BCM2042 chip and antenna can be maximized:

- Place voltage regulator close to the battery terminals.
- Smaller value bypass capacitors should be placed as close to the chip feed in/out as possible, while the larger value capacitors can be conveniently placed further away.
- Sufficient number of GND via holes is important. Length of GND traces must be minimized.
- Use short, wide and low inductance traces for all power supply traces.
- The power supply traces used for digital and analog circuit blocks should be separated.
- The location of decoupling capacitors should be as close as possible to device's supply input pins (VDD/VSS or VCC/GND).

Please refer to Broadcom Application Note (Document 2042-AN200-R) for sample mouse PCB with suggested placements, as well as the antenna keep out areas.

Bluetooth Dongle with BCM2045

Bluetooth dongles are needed only on PCs or laptops without built-in Bluetooth capability. The Bluetooth dongle included in this reference design kit is tightly integrated with industry-leading WIDCOMM Bluetooth Software (by Broadcom Corporation). To use the dongle, please install the WIDCOMM Bluetooth Software into the PC or laptop. The driver (WIDCOMM Bluetooth Software) is available with the reference design kit CD.

The Bluetooth dongle consists of:

- EEPROM/Flash memory
- An "Auto-pair" button for Bluetooth pairing with Broadcom Bluetooth HID devices
- Broadcom BCM2045 Bluetooth chip

Some Details on ADNK-3043-BRBT

The ADNK-3043-BRBT reference design mouse unit allows users to evaluate the performance of the Optical Tracking Engine (sensor, lens, LED assembly clip, LED) over a USB connection, using a BCM92042MDX-B88 Bluetooth ROM module and receiver dongle. 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 with standard 3-button HID driver loaded. For PC or laptops without embedded Bluetooth, the dongle driver or Bluetooth stack should be installed.

Functionality

Three-button, scroll wheel combo-mouse.

USB Operating Mode

Hot pluggable with USB port. The PC does not need to be powered off when plugging or unplugging the mouse dongle.

To Disassemble the ADNK-3043-BRBT Unit

The ADNK-3043-BRBT comprises of the plastic mouse casing, printed circuit board (PCB), lens, and buttons (See Figure 5). Unscrewing the one screw located at the base of the unit can open the ADNK-3043-BRBT unit. Lifting and pulling the PCB out of the base plate can further disassemble the mouse unit**.**

Caution: The lens is not permanently attached to the sensor and will drop out of the assembly.

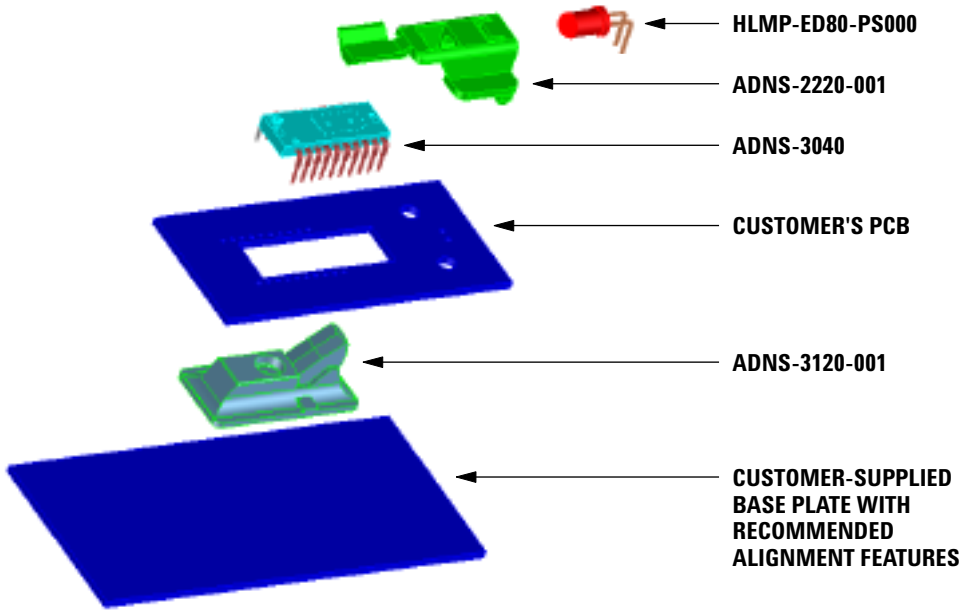


Figure 5. Exploded view drawing of optical tracking engine with ADNS-3040 optical mouse sensor

While reassembling the components, please make sure that the Z height (distance from lens reference plane to surface) is valid. Refer to Figure 6.

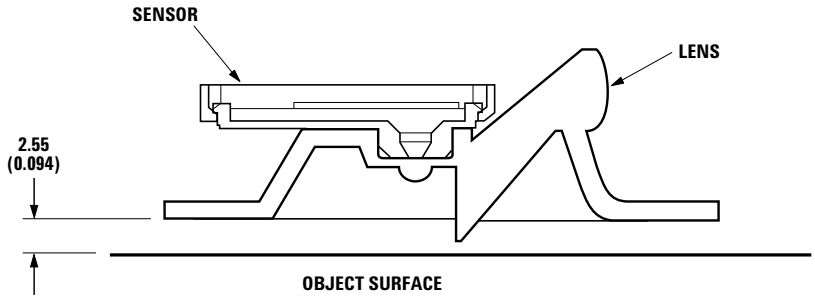


Figure 6. Distance from lens reference plane to surface

Regulatory Requirements

- Passes FCC B and worldwide analogous emission limits when assembled into a mouse with unshielded cable and following Avago Technologies recommendations.
- Passes EN61000-4-4/IEC801-4 EFT tests when assembled into a mouse with unshielded cable and following Avago Technologies recommendations.
- UL flammability level UL94 V-0.
- Provides sufficient ESD creepage/clearance distance to avoid discharge up to 15 kV when assembled into a mouse according to usage instructions above.
- For eye safety consideration, please refer to the document, Eye Safety Calculation AN1228, which is available on the website *http://www.avagotech.com*.
- The 15.0 kW resistor is determined by the absolute maximum rating of 50 mA for the HLMP-ED80. The other resistor values for brighter bins will guarantee sufficient intensity with reduced power.

Below is the summary of the components contained in the ADNK-3043-BRBT Designer's Kit.

Sensor

The sensor technical information is contained in the ADNS-3040 Data Sheet.

Bluetooth ROM Module

For technical information about the hardware implementation in the BCM92042MDX-B88 module, please refer to the BCM2042 chip datasheet. For Bluetooth dongle related information, please refer to BCM2045 chip datasheet.

As for mouse software support, please refer to the document located inside Broadcom's BCM2042 Firmware Development Kit (FDK). For further information, please contact Broadcom Corporation.

Lens

The lens technical information is contained in the ADNS-3120-001 Data Sheet.

LED Assembly Clip

The information on the assembly clip is contained in the ADNS-2220 Data Sheet.

LED

The LED technical information is contained in the HLMP-ED80-XX000 Data Sheet and Application Note AN-1228. Additional application notes regarding Eye Safety Requirements are also available at Avago Technologies' website.

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.

Reference Design Documentation – Gerber File

The Gerber File presents detailed schematics used in ADNK-3043-BRBT in PCB layout form. See Appendix C for more details.

Overall Circuit

A schematic of the overall circuit is shown in Appendix A of this document. Appendix B lists the bill of materials.

Firmware Implementation

The Bluetooth firmware includes the core firmware which resides in the BCM2042 on-chip ROM and the configuration file which resides in the external EEPROM. The core firmware implements the general Bluetooth protocol functionality including Bluetooth Baseband, LMP, GAP, L2CAP, general HID functionality, SDP query, default mouse/keyboard implementation, etc. The core firmware for BCM2040 ROM resides in ROM and can not be modified.

The configuration file which can be modified or customized for specific HID devices includes the following:

1. Configuration entries

HID Configuration records including device name, Product ID, Vendor ID, HID report descriptor, etc. which can be edited by any text tool.

2. Application firmware code

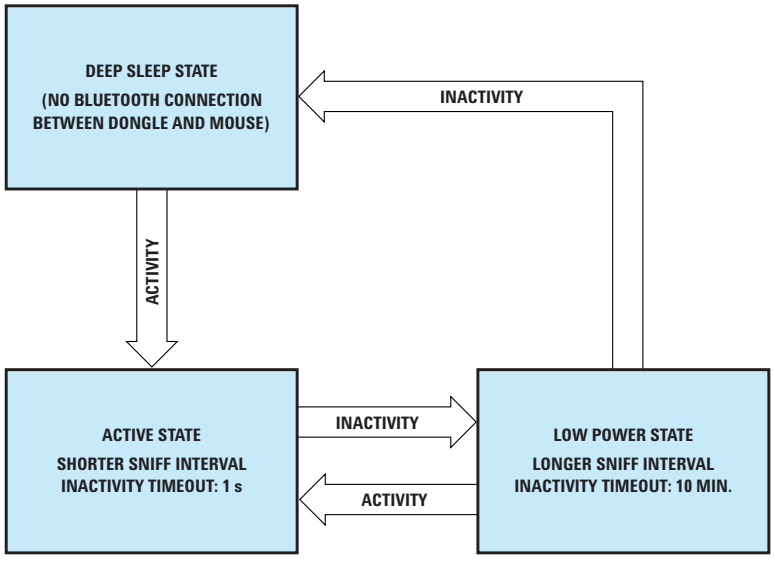
This firmware code overrides relevant default HID functionality in the BCM2042 chip on the module. Special functionality that is not included in the core firmware can also be implemented through this.

3. Core firmware patch code

Firmware patch to fix the bugs in the core firmware (can be done through Broadcom only).

Power Saving Algorithm

The diagram below shows the general power saving algorithm used in the ADNK-3043-BRBT mouse. Sniff intervals and inactivity time out are programmable. However, there is a trade off between performance (for example, motion or wake up latency) and battery life.



For details, please refer to Broadcom BCM2042 Firmware Development Kit (FDK).

Bluetooth Mouse Pairing Process

For users with built-in Bluetooth PCs or laptops, follow these steps to pair the ADNK-3043-BRBT to your PC or laptop for the first time:

1. Press, hold and release the "Discovery" connect button on the back of the ADNK-3043-BRBT mouse
2. Wait for the driver to discover the mouse
3. Select the discovered mouse to be paired

For users with conventional PCs or laptops, follow these steps to pair the ADNK-3043-BRBT to your PC or laptop for the first time:

1. Press, hold and release the "Auto-Pair" button on the dongle till the blue LED is blinking.
2. Press, hold and release the "Discovery" connect button on the back of the ADNK-3043-BRBT mouse
3. Wait for the driver to discover the mouse
4. Select the discovered mouse to be paired

Once these steps are completed, connection is then accomplished.

Appendix A: Schematic Diagram of the Mouse Main Board

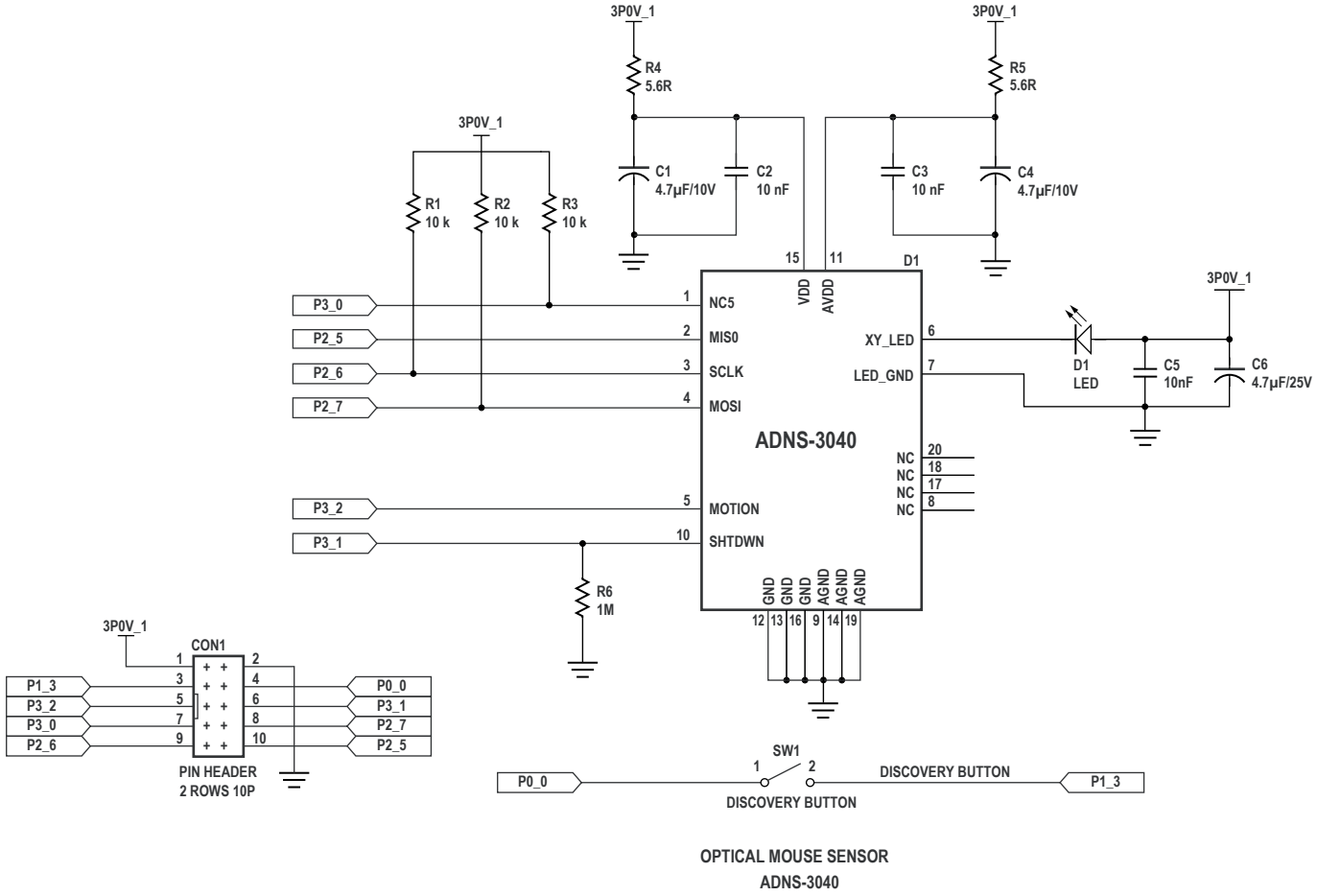


Figure A1. Schematic diagram of optical mouse sensor

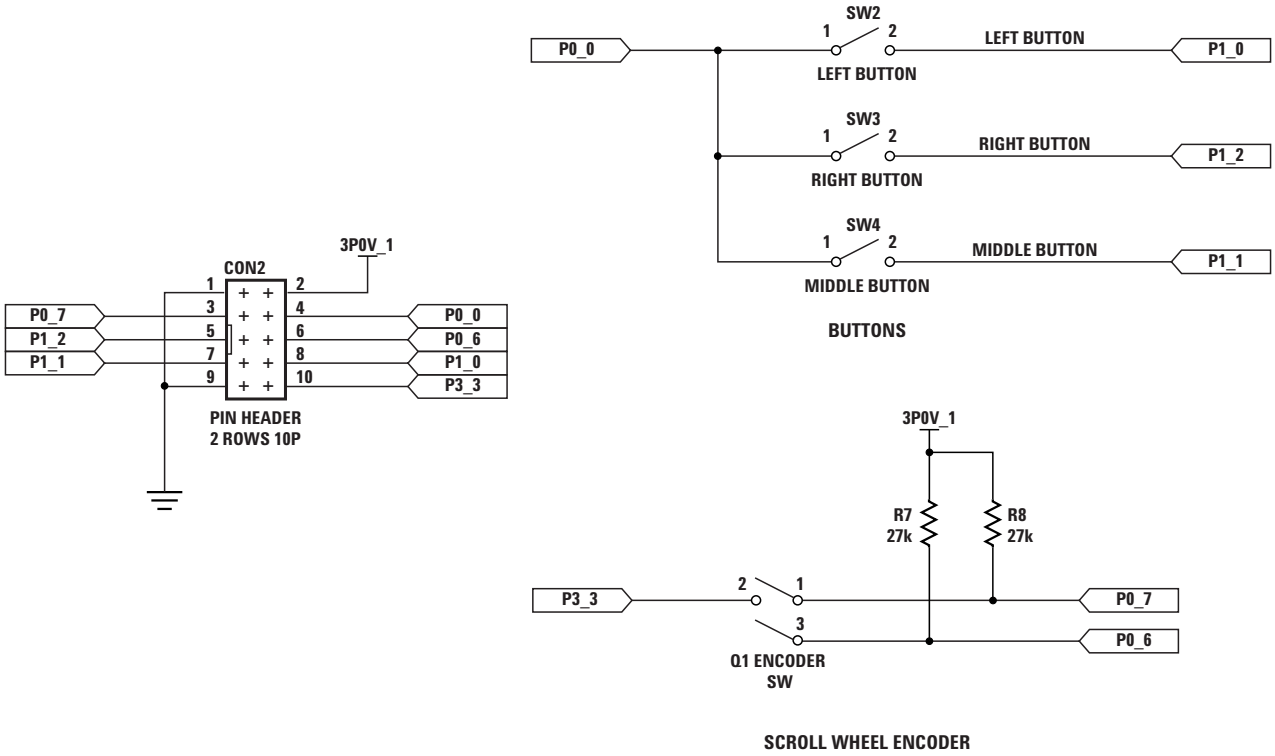


Figure A2: Schematic diagrams of buttons and Z-Wheel main board

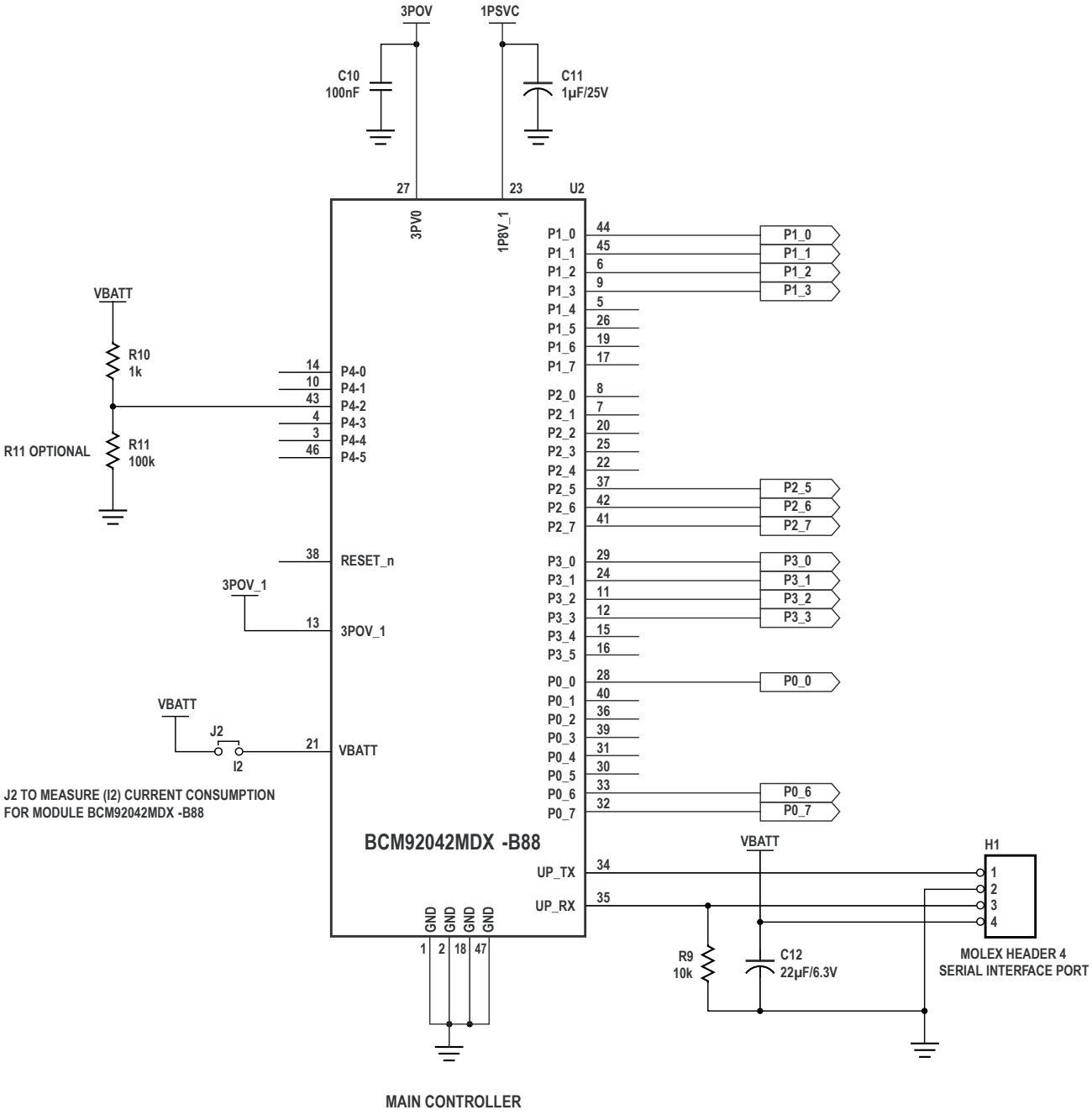


Figure A3. Schematic diagram of Bluetooth ROM module main board

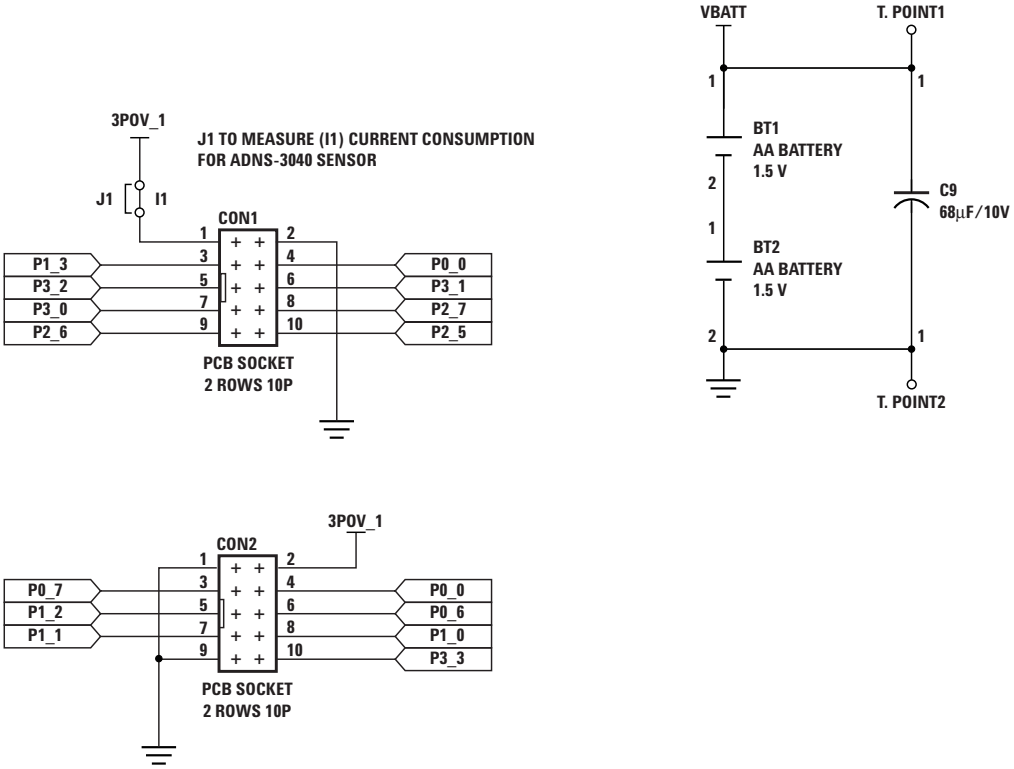


Figure A4. Sub-schematic diagram of Bluetooth ROM module main board

Note: For technical information related to the USB Bluetooth dongle, please contact Broadcom.

Appendix B: Bill of Materials for ADNK-3043-BRBT Bluetooth Mouse Designer's Kit

Table B1. Bill of Materials for ADNK-3043-BRBT Bluetooth Mouse Designer's Kit Main Board

Item	Description	Qty	Value	Reference
1	CERAMIC CAPACITOR	1	100 nF 50 V	C10
2	TANTALUM CAPACITOR	1	1 uF 25 V	C11
3	TANTALUM CAPACITOR	1	22 uF 6.3 V	C12
4	TANTALUM CAPACITOR	1	68 uF 10 V	C9
5	RESISTOR	1	10 k, 5%	R9
6	RESISTOR	1	1 k, 1%	R10
7	RESISTOR	1	100 k, 1%	R11
8	BLUETOOTH MODULE	1	BCM92042MDX-B88	U2
9	CONN HEADER 4POS 1.25 mm VERT SMD	1	CONN HEADER 4POS	H1
10	RECEPTACLE 4POS MOLEX 1.25 mm	1	RECEPTACLE 4POS	NOT SHOWN ON SCHEMATIC
11	PCB SOCKET 2 ROW 10P	2	PCB SOCKET	CON1,CON2
12	PIN HEADER SINGLE ROW	2	PIN HEADER 2P	J1,J2

Table B2. Bill of Materials for ADNK-3043-BRBT Bluetooth Mouse Designer's Kit Z-Wheel and Button Sub-Board

Item	Description	Qty	Value	Reference
1	RESISTOR	1	27 k, 1%	R7,R8
2	ENCODER	1	Z-ENCODER	Q1
3	MICROSWITCH	3	MICROSWITCH	SW2,SW3,SW4
4	PIN HEADER 2 ROW 10P	2	PIN HEADER 10P	CON1,CON2

Table B3. Bill of Materials for ADNK-3043-BRBT Bluetooth Mouse Designer's Kit Optical Sensor Sub-Board

Item	Description	Qty	Value	Reference
1	RESISTOR	1	1 M, 5%	R6
2	RESISTOR	3	10 k, 5%	R1,R2,R3
3	RESISTOR	2	5.6 R, 5%	R4,R5
4	TANTALUM CAPACITOR	2	4.7 uF 10 V	C1,C4
5	TANTALUM CAPACITOR	1	1 uF 25 V	C6
6	CERAMIC CAPACITOR	3	10 nF 50 V	C2,C3,C5
7	MICROSWITCH	1	MICROSWITCH	SW1
8	LED	1	LED	D1
9	OPTICAL MOUSE SENSOR	1	ADNS-3040	U1
10	OPTICAL SENSOR LENS	1		NOT SHOWN ON SCHEMATIC

Appendix C: PCB Layout

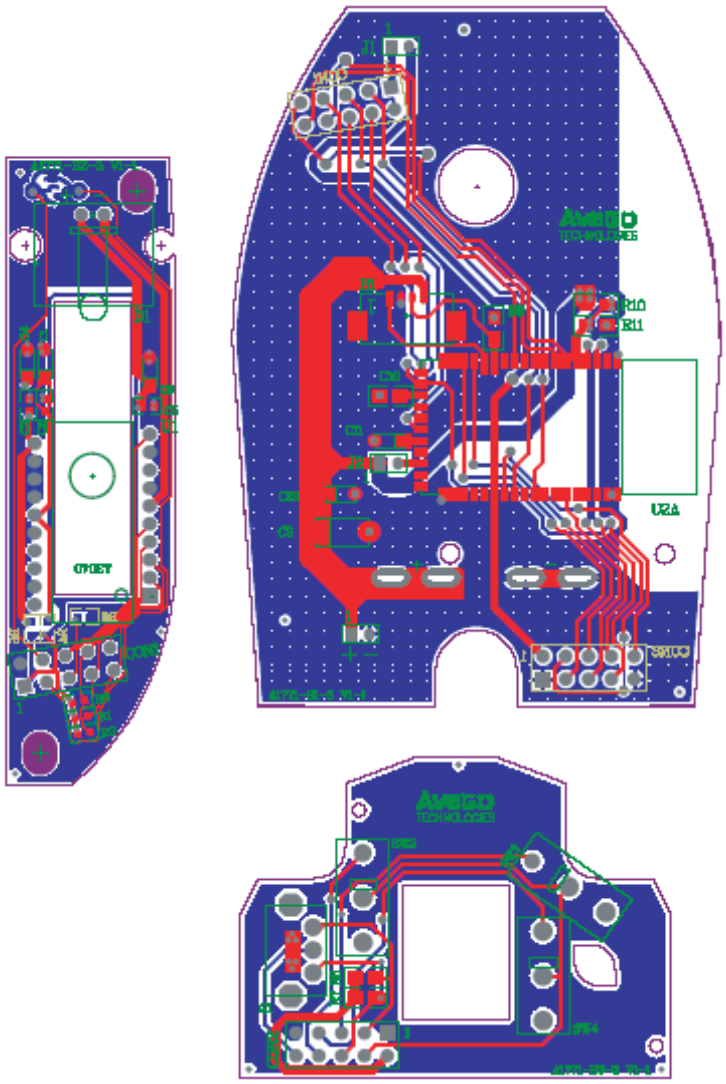


Figure C1. PCB layout for main board, sub-board 1 and sub-board 2 of ADNK-3043-BRBT wireless optical mouse designer's kit

Note: For technical information related to the USB Bluetooth dongle, please contact Broadcom.

Appendix D: Kit Components

The designer's kit contains components as follows:

Part Number	Description	Name
ADNK-3043-BRBT Mouse Set	Optical Mouse Reference Design Unit includes: - Wireless Mouse - USB-Bluetooth Dongle	Reference Design Unit
ADNS-3040	Solid-State Optical Mouse Sensor	Sensor
ADNS-3120-001	Trim Lens Plate	Lens
ADNS-2220	LED Assembly Clip (Black)	LED Clip
HLMP-ED80-PS000	639 nm T 1 _ (5 mm) Diameter LED	LED
ADNK-3043-BRBT CD	Includes Documentation and Support Files for ADNK-3043-BRBT Documentation a. ADNS-3040 Data Sheet b. BCM2042 Product Brief c. BCM2045 Product Brief d. ADNS-3120-001 Data Sheet e. ADNS-2220 Data Sheet f. HLMP-ED80-XX000 LED Data Sheet Hardware Support Files a. ADNK-3043-BRBT Mouse BOM List b. ADNK-3043-BRBT Mouse Schematic c. ADNK-3043-BRBT Mouse Layout Drawing d. ADNK-3043-BRBT Gerber File e. IGES Base Plate Feature File Software Support Files a. WIDCOMM Bluetooth Software *For more information regarding BCM92040MDX-B88 and software/firmware, please contact Broadcom directly.	

For product information and a complete list of Broadcom's distributors, please go to our website.
www.support.broadcom.com

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

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