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T E C H N O L O G I E S

Design Guide

Introduction

The Universal Serial Bus (USB) is an industry standard serial interface between a computer and peripherals such as a mouse, joystick, keyboard, UPS, etc. This design guide describes how a cost-effective USB optical mouse can be built using Avago Technologies small form factor ADNS-5020-EN optical mouse sensor and the powerful Sunplus SPCP18A-13C microcontroller. The document starts with the basic operations of a computer mouse peripheral followed by an introduction to the Avago Technologies ADNS-5020-EN Optical Navigation Sensor and Sunplus SPCP18A-13C microcontroller. A schematic of the SPCP18A-13C microcontroller to the ADNS-5020-EN optical mouse sensor and buttons of a standard mouse can be found in Appendix A. The SPCP18A-13C data sheet is available from the Sunplus web site at www.sunplus.com. The ADNS-5020-EN data sheet is available from the Avago web site at http://www.avagotech.com/. USB documentation can be found at the USB Implementers Forum web site at www.usb.org.

Optical Mouse Basics

The optical mouse measures changes in position by optically acquiring sequential surface images (frames), and mathematically determining the direction and magnitude of movement. A mechanical quadrature encoder provides the Z-wheel movement. Each of the button switch is pulled up normally and provides a GND when pressed. This design guide shows how to connect to and manage a standard configuration of mouse hardware, as well as handle the USB protocol. This protocol provides a standard way of reporting mouse movement and button presses to the PC.

Introduction to ADNS-5020-EN Optical Mouse Sensor

Avago Technologies' ADNS-5020-EN optical sensor is used in this reference design as the primary navigation engine. This Optical Navigation Technology contains an Image Acquisition System, a Digital Signal Processor, and a three-wire serial port. The SPCP18A-13C periodically reads the ADNS-5020-EN's Delta_X and Delta_Y registers to obtain any horizontal and vertical motion information happening as a result of the mouse being moved. The three-wire synchronous serial port is used to set and read parameters in the ADNS-5020-EN, and to read out the motion, (delta) X and (delta) Y information.

This motion information will be reported to the PC to update the position of the cursor. The advantages of using ADNS-5020-EN optical sensor are: good tracking accuracy, small form factor, sensor programming flexibility via SPI port, and the automatic frame rate feature. Furthermore, ADNS-5020-EN sensor has built-in oscillator and on-chip LED driver to minimize external components. Additionally, Burst mode is another special serial port operation mode which may be used to reduce the serial transaction time for motion read operation

Motion Read is activated by reading the Motion_Burst register. The ADNS-5020-EN will respond with the contents of the Delta_X, Delta_Y, SQUAL, Shutter_Upper, Shutter_Lower, Maximum_Pixel and Pixel_Sum registers in that order.

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

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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 1, 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.

Introduction to the SPCP18A-13C

The Sunplus SPCP18A-13C is a low speed USB microcontroller, specially designed for low speed USB wired mouse with ADNS-5020-EN sensor application. The chip supports up to 5 button modes and adjustable resolution (500/1000cpi) via the application straps during power-on reset. 16-pin (3-buttons) or 18-pin (3/5-buttons) PDIP and SOP packages are available.

Serial Peripheral Interface (SPI)

The SPCP18A-13C provides a SPI compatible interface. The SPI circuit supports byte serial transfer in either Master or Slave mode. The integrated SPI circuit allows the SPCP18A-13C to communicate with external SPI compatible hardware, in this case the ADNS-5020-EN.

Hardware Implementation

The standard hardware to implement a mouse is shown in Figure 1. For X and Y movement, the optical sensor is used. The Z- wheel movement is detected by a set of mechanical encorder that output quadrature signals.
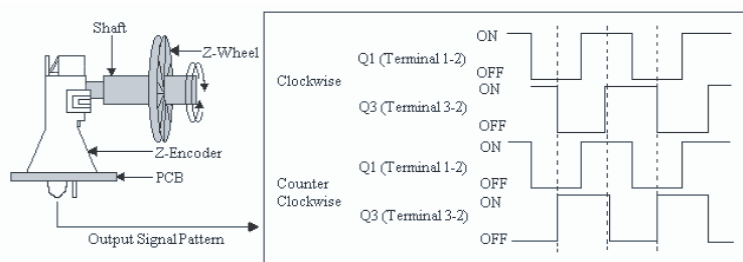

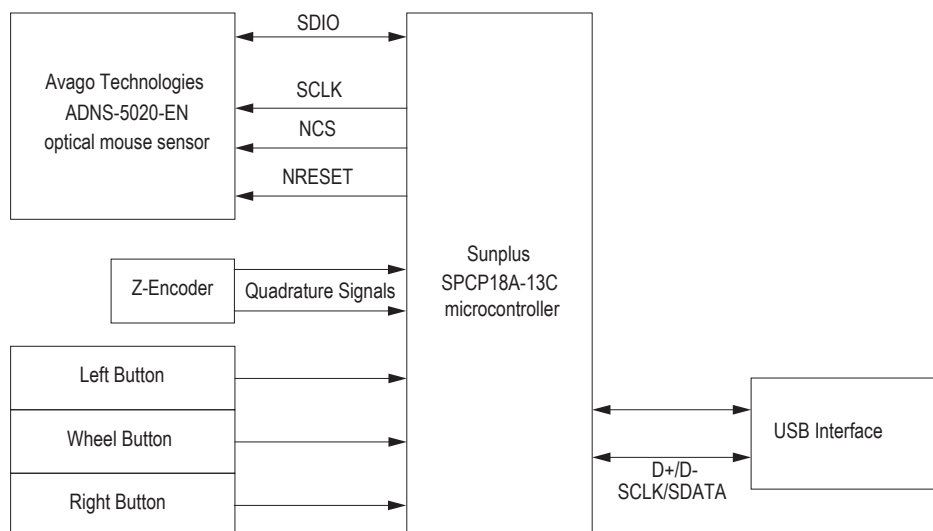Figure 1. Mechanical Z-Wheel Output Signal Generation

Figure 2. SPCP18A-13C –ADNS-5020-EN Optical Mouse Hardware Block Diagram

ADNK-5023-SP02 Designer's Kit – Optical Mouse

The ADNK-5023-SP02 reference design mouse unit allows users to evaluate the performance of the Optical Tracking Engine (sensor, lens, LED assembly clip, LED) over USB connection, using a Sunplus microcontroller. 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 with standard 3-button USB mouse driver loaded.

Functionality

3-button, scroll wheel mouse.

Operating (For USB 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-5023-SP02 Unit

The ADNK-5023-SP02 comprises of the plastic mouse casing, printed circuit board (PCB), lens, buttons, and USB cable. (See Figure 2.) Unscrewing the one screw located at the base of the unit can open the ADNK-5023-SP02 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.

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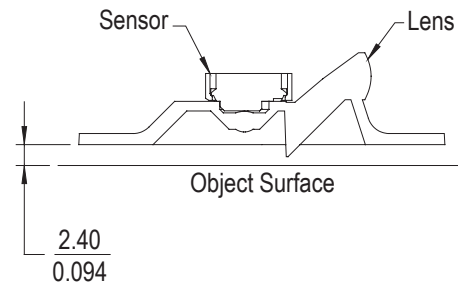

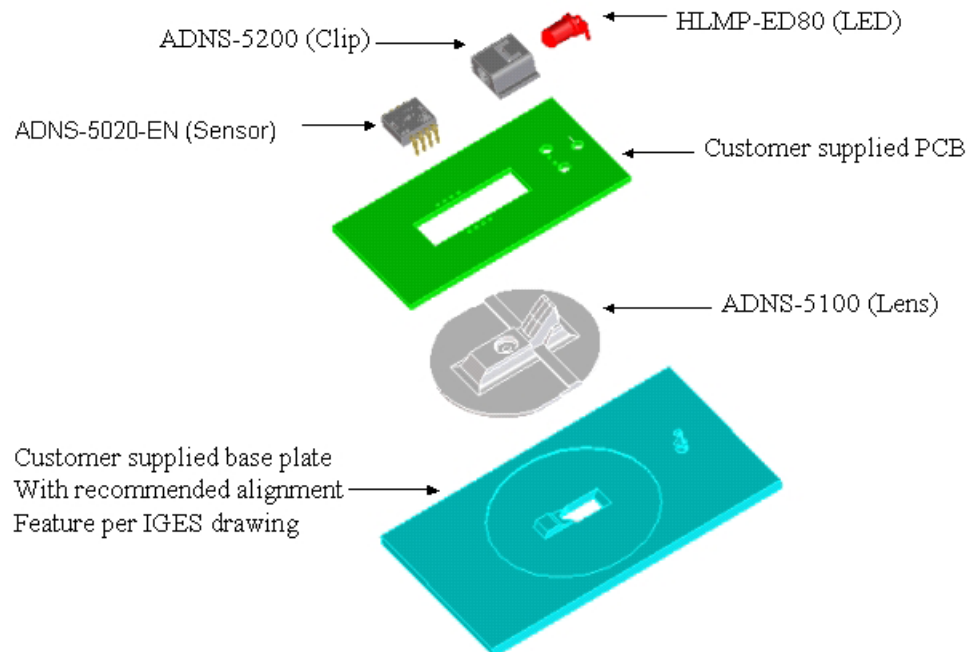**Figure 4. Distance from lens reference plane to surface**

Figure 3. Exploded view drawing of optical tracking engine with ADNS-5020-EN optical mouse sensor.

Below is the summary of the components contained in the ADNK-5023-SP02 Designer's Kit.

Sensor

The sensor technical information is contained in the ADNS-5020-EN Data Sheet.

USB Controller

Technical information on the Sunplus microcontroller is contained in the SPCP18A-13C Data Sheet.

Lens

The lens technical information is contained in the ADNS-5100 Data Sheet. The flange on the standard ADNS-5100 lens is for ESD protection.

LED Assembly Clip

The information on the assembly clip is contained in the ADNS-5200 Data Sheet.

LED

The LED technical information is contained in the HLMP-ED80-XX000 Data Sheet.

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-5023-SP02 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.

Appendix A: Schematic Diagram of the Overall Circuit

CPI-LED	
CPI	LD2 Flash Freq
500 CPI	2Hz
800 CPI	6Hz
1000 CPI	12Hz

3Key / 5key Strap

R2	R1	Button
Mounted	Not Mounted	5 Key
Not Mounted	Mounted	3 Key

SW-ISS Inhibit

R5	SW-ISS
Mounted	Disable
Not Mounted	Enable

Figure A1. Circuit-level block diagram for ADNK-5023-SP02 designer's kit optical mouse using the Avago Technologies ADNS-5020-EN optical mouse sensor and Sunplus SPCP18A-13C 18-pin package

Appendix B: Bill of Materials for Components Shown on schematic

No.	Descriptions	Footprint	Designators	Qty
1	Header friction lock, 2.54mm		JP1	1
2	Multilayer ceramic cap 2.2uF 16V	1206	C4	1
3	Multilayer ceramic cap 4.7uF 50V	1206	C3,C8	2
4	Multilayer ceramic cap 100nF 16V	0603	C1,C2,C5,C7	4
5	Multilayer ceramic cap 3.3uF 16V	1206	C6	1
6	Resistor 100k 1% 0.1W	0805	R1,R2	2
7	Resistor 10k 5% 0.1W	0805	R3	1
8	Resistor 3.3k 5% 0.1W	0805	R5	1
9	Crystal 6MHz		XT1	1
10	z-encoder		Z1	1
11	IC SPCP18A-13C		U1	1
12	Sensor ADNS-5020E		U2	1
13	LED HLMP-ED80		LD1	1
14	SPDT switch		SW1,SW2,SW3	3
15	IC turn pin socket DIL 0.3" 20 ways		U1*	1

Appendix C: PCB Layout
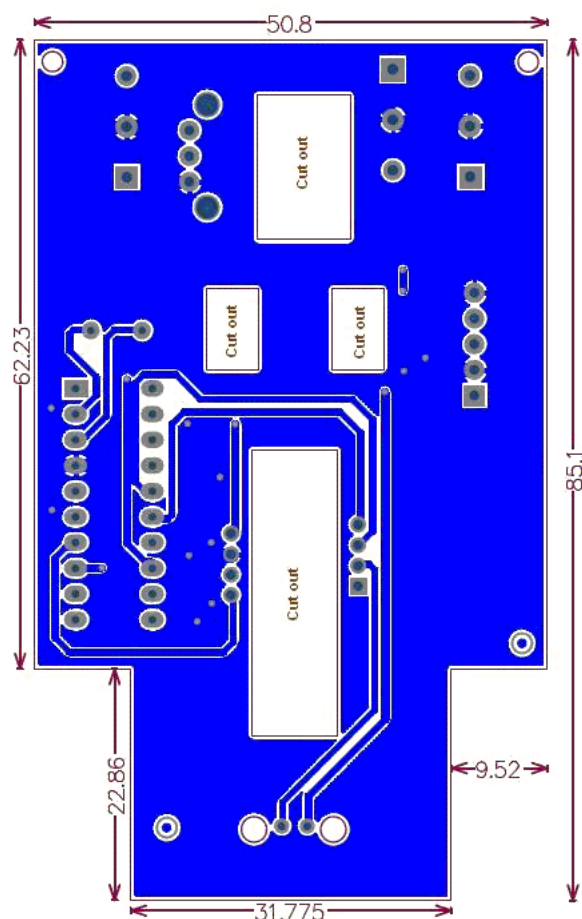
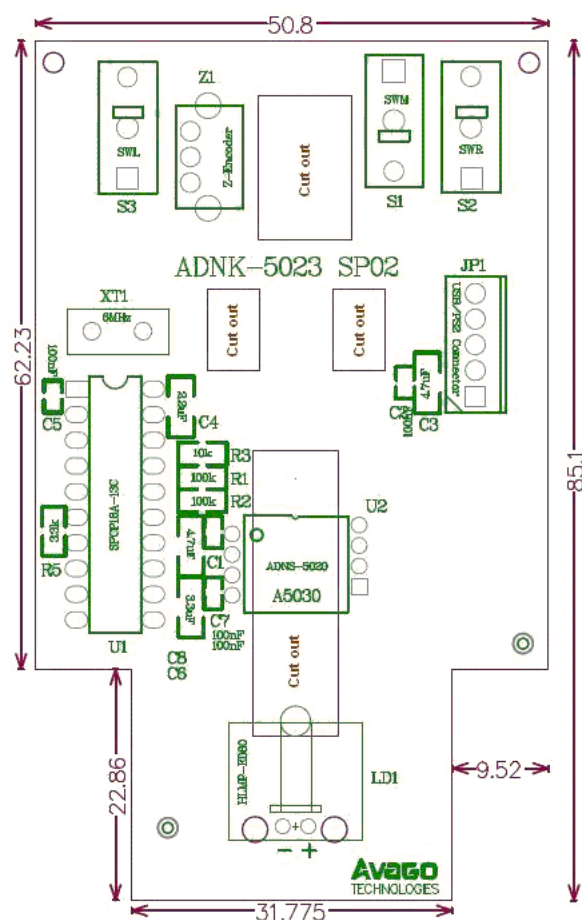**Figure C1. PCB Schematic (Bottom Layer)**

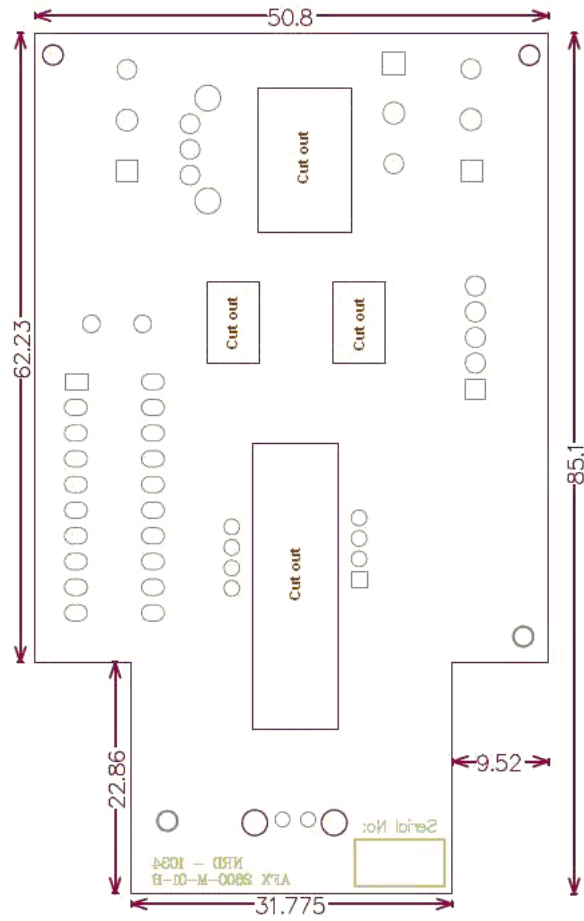**Figure C2. PCB Schematic (Top Overlay)**

Figure C3. PCB Schematic (Bottom Overlay)

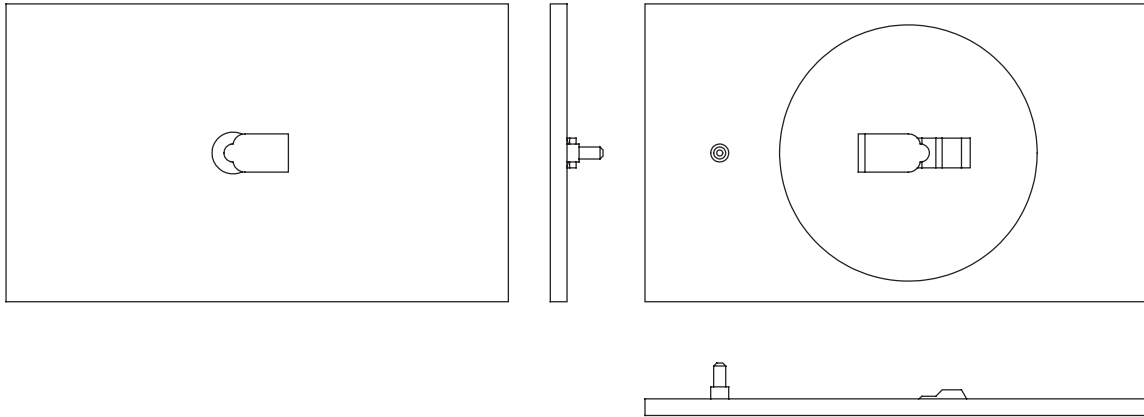## Appendix D: Base Plate Feature

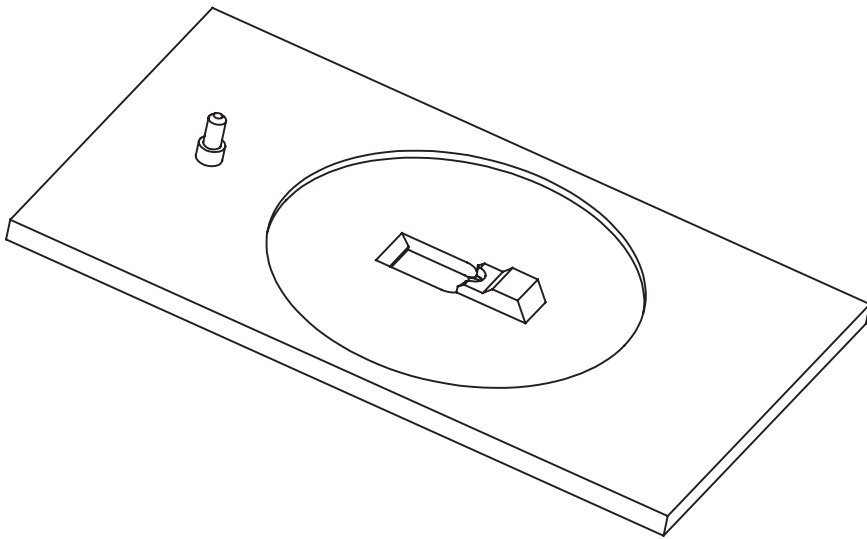**Figure D1. Bottom, top and side view of base plate**

Figure D2. Overall view of base plate
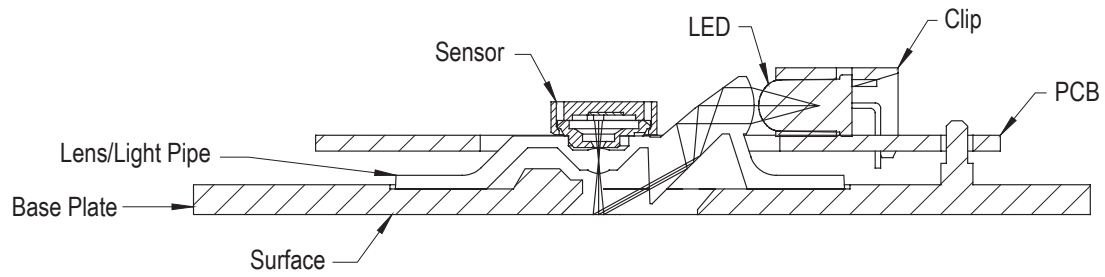
Appendix E: Sectional view of PCB assembly

Figure E1. Sectional view of PCB assembly highlighting all optical mouse components (optical mouse sensor, clip, lens, LED, PCB, and base plate).

Kit Components

The designer's kit contains components as follows:

Part Number	Description	Name	Quantity
ADNK-5023-SP02 Mouse	Reference Design Mouse	Reference Design Unit	1
ADNS-5020-EN	Solid-State Optical Mouse Sensor	Sensor	5
SPCP18A-13C	Sunplus USB Controller	USB Controller	5
ADNS-5100	Round Lens Plate	Lens	5
ADNS-5100-001	Trim Lens Plate	Lens	5
ADNS-5200	LED Assembly Clip (Transparent)	LED Clip	5
HLMP-ED80-XX000	639 nm T-1¾ (5 mm) Diameter LED	LED	5
ADNK-5023-SP02 CD	Includes Documentation and Support Files for ADNK-5023-SP02	1	

Documentation
ADNS-5020-EN Data Sheet
ADNK-5023-SP02 Design Guide
ADNK-5023-SP02 Kit Overview
SPCP18A-13C Data Sheet
ADNS-5100 Data Sheet
ADNS-5200 Data Sheet
HLMP-ED80-XX000 LED Data Sheet

Hardware Support Files
ADNK-5023-SP02 BOM List
ADNK-5023-SP02 Schematic
IGES Base Plate Feature File
Gerber File

Software Support Files
Microcontroller Firmware

Ordering Information

For ordering information, please contact your local Avago Technologies sales representative.

At Avago Technologies call (800)235-0312, visit the website at http://www.avagotech.com/

At Sunplus call +886-3-5786005 ext. 3288 or visit the web site at www.sunplus.com

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