

## 1 The AS5046 Adapter PCB

The AS5046 adapter PCB is a simple circuit allowing customers to test and evaluate the AS5046 rotary encoder rapidly without having to build their own test fixture or PCB.

The PCB can be used as standalone unit or plugged onto the AS5046 demo board as external encoder. For Standalone operation, it can be supplied with 3.3V, 5V or 7.5...12V DC supply voltages.

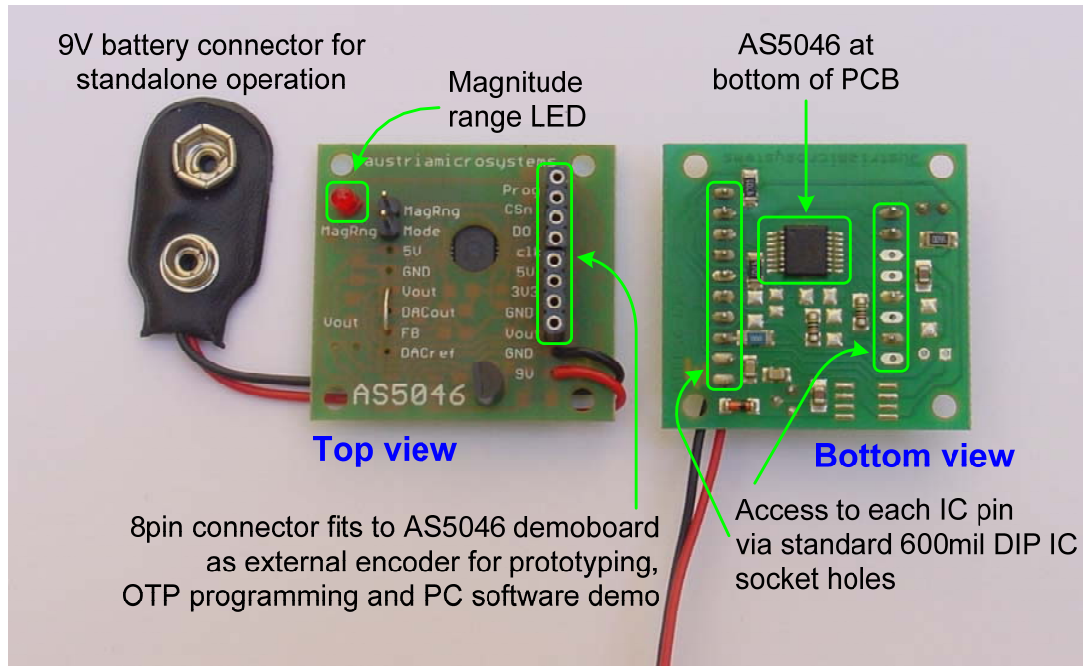


Figure 1: AS5046 adapter PCB: top and bottom view

### Features:

- 100mil connector for direct connection to AS5046 demo board
- Provision for a 600mil DIP socket
- Hole in PCB to center a 6mm magnet at the bottom of the IC
- LED for MagRng output
- On-board 5V linear voltage regulator for 7.5...12V supplies
- 9V battery connector for standalone operation
- Dimensions: 35mm x 37mm (1.38 x 1.46 inch)

## 2 General Description

The AS5046 is a system-on-chip, combining integrated Hall elements, analog front end and digital signal processing in a single device. It provides incremental output signals and the absolute angular position of a magnet that is placed either above or below the device. The AS5046 can be configured to specific customer requirements by programming the integrated OTP (one time programmable) register. An internal voltage regulator allows the AS5046 to operate at either 3.3 V or 5 V supplies.

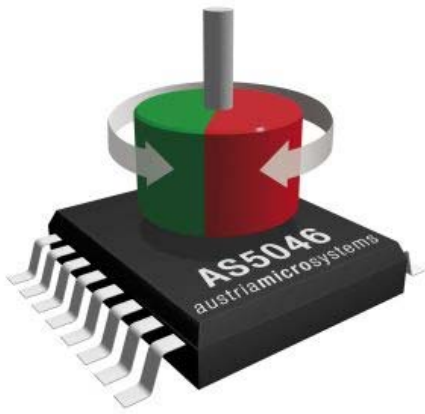


Figure 2: Typical arrangement AS5046 and magnet

## 3 Pin Configuration

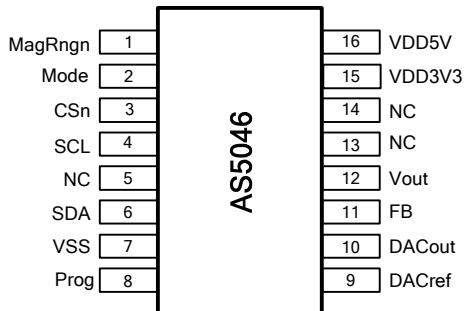


Figure 3: Pin configuration SSOP16

## 4 Pin Description

Pin	Symbol	Type	Description
1	MagRngn	DO_OD	Magnet Field Magnitude RaNGe warning; active low, indicates that the magnetic field strength is outside of the recommended limits.
2	Mode	DI_PD, ST	Mode input. Select between low noise (open, low) and high speed (high) mode. Internal pull-down resistor
3	CSn	DI_PU, ST	Chip Select, active low; Schmitt-Trigger input, internal pull-up resistor (~50kΩ). Must be connected to VSS for I <sup>2</sup> C data transmission.
4	SCL	DI,ST	Serial Clock Line. Clock input for I <sup>2</sup> C data transmission
5	NC	-	must be left unconnected
6	SDA	DIO	Serial Data Line. Bi-directional I/O for I <sup>2</sup> C data transmission
7	VSS	S	Negative Supply Voltage (GND)
8	Prog	DI_PD	OTP Programming Input. Internal pull-down resistor (~74kΩ). Should be connected to VSS if programming is not used
9	DACref	AI	DAC Reference voltage input for external reference
10	DACout	AO	DAC output (unbuffered, R <sub>i</sub> ~8kΩ)
11	FB	AI	Feedback, OPAMP inverting input
12	Vout	AO	OPAMP output
13	NC	-	Must be left unconnected
14	NC	-	Must be left unconnected
15	VDD3V3	S	3V-Regulator Output for internal core, regulated from VDD5V. Connect to VDD5V for 3V supply voltage. Do not load externally.
16	VDD5V	S	Positive Supply Voltage, 3.0 to 5.5 V

Table 1: Pin description SSOP16

## 5 Principle of Operation

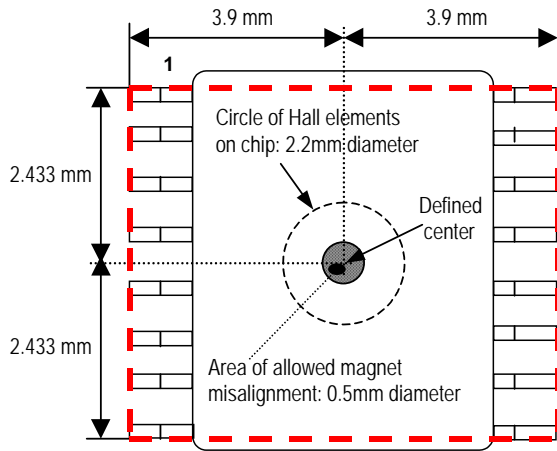


Figure 4: Tolerances of magnet placement

The AS5046 chip consists of a ring of Hall elements, placed at the center of the IC at a circle diameter of 2.2mm (86.6mil).

The Hall elements pick up the field of a magnet, placed atop this Hall array circle. This information is digitized and fed into a digital signal processor (DSP), which calculates the angle of the magnet with a resolution of 0.0879 degrees or 4096 positions per revolution (10bit) at a sampling rate of 96 $\mu$ s (10kHz; Default) or 384 $\mu$ s (2.6kHz).

The digital angle information is available in several formats: as serial 10-bit data stream, as pulse-width modulated (PWM) signal or as quadrature incremental signal.

### 5.1 Magnet Considerations

A magnet, having one north / one south pole in the horizontal axis is placed right above the ring of Hall elements (see Figure 2). The magnet does not necessarily need to be circular, it can be rectangular as well, as long as the north and south pole are arranged horizontally over the center of the Hall array ring.

The magnetic field strength along this ring should be in the range of  $\pm 45 \dots 75$  milliTesla (mT).

#### 5.1.1 Magnet Size

The size of the magnet should be at least the size of the Hall array ring (2.2mm). Smaller magnets are more critical in terms of misalignment due to the non-linear magnetic field distribution along the circumference of the magnet. The recommended magnet diameter is 4...6mm

#### 5.1.2 Magnet Distance and Material

To achieve the required field strength at a reasonable distance ( $-0.5 \dots 5$ mm), it is recommended to use rare-earth magnets, such as Samarium-Cobalt (SmCo) or Neodyme-Iron-Boron (NdFeB) magnets.

#### 5.1.3 Magnet Misalignment

In theory, the magnet misalignment is not critical for this type of angular measurement. In practice however, magnets are not perfectly linear. The magnetic field strength does not increase linearly with the radius. As you get towards the boundary of the magnet, the magnetic field comes to a maximum and then weakens as you move further away from the center. Therefore, a magnet should be chosen, that is still in the linear range at a  $< 3$ mm diameter.

#### 5.1.4 Non-linearity Errors

A non-linear magnetic field results in a non-sinusoidal representation of the magnet, which in turn causes non-linearity in the calculated angle (calculated angle differs from actual angle).

With a perfectly centered magnet, the maximum error is  $\pm 0.5$  degrees. This error is caused by internal mismatch and gain errors.

With the recommended 4mm magnet (Bomatec BMN-35H), the maximum error of  $\pm 1.4$  degrees (including internal errors and temperature related errors) can be achieved while the magnet is off-center by a radius of  $< 0.25$ mm (see Figure 4).

## 6 AS5046 Adapter PCB Schematic

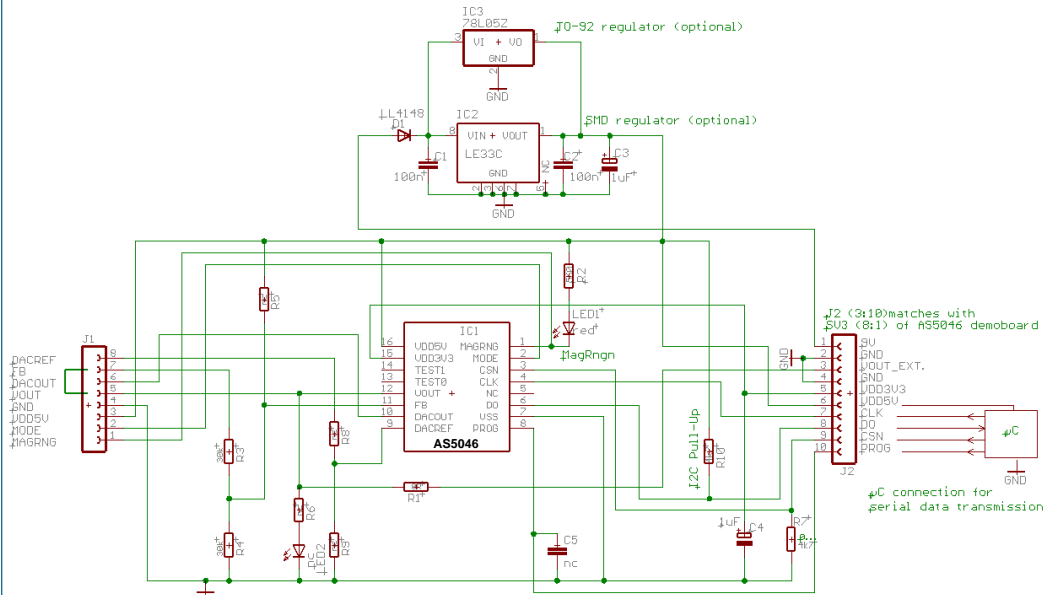


Figure 5: AS5046 adapter PCB schematic

For normal operation, the only required external components are the buffer cap at VDD3V3 (C4) and the pull-down resistor at CSn (R7; 0Ω...4k7).

The PCB operates at several power supply levels:

### Power Supply Options:

Supply voltage	Apply at	Ext. voltage regulator IC2 or IC3	Digital I/O level	Remark
3.0...3.6V	VDD5V and VDD3V3	not required *)	3.0...3.6V	short VDD5V and VDD3V3
4.5...5.5V	VDD5V	not required *)	4.5...5.5V	
7.5...20V	ext. voltage regulator (pin 1, J2)	3.3V type, e.g. LE33C (ST Micro)	3.3V	short VDD5V and VDD3V3
7.5...20V	ext. voltage regulator (pin 1, J2)	5.0V type e.g. 75L05	5.0V	PCB delivery status

\*) if already installed, external voltage regulator can be left installed.

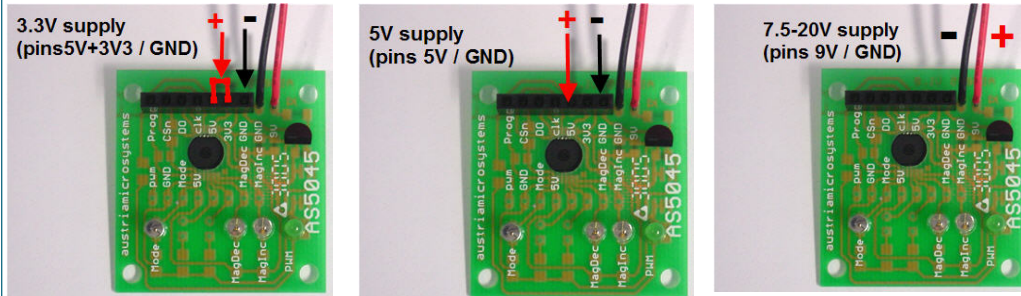


Figure 6: How to connect various power supply levels to the adapter PCB

**Output Modes:**

- Absolute angle information  
 To access the 10-bit absolute angle information, an external microcontroller must be connected as shown in Figure 5. Make sure that the controller is able to drive the CSn pin with the connected pull-down resistor (R7). If necessary, remove this resistor.  
 The clock rate can be as high as 1MHz. There is no minimum clock rate. Data can also be clocked manually. The digital I/O's of the AS5046 are buffered by VDD5V, therefore the digital I/O's of the controller should be at the same voltage level (see power supply options table).
- Analog output  
 No additional components are required. The voltage at the Vout pin (pins 3 of J1) indicates the position of the encoder. (see datasheet).

**Programming (zapping) the Chip:**

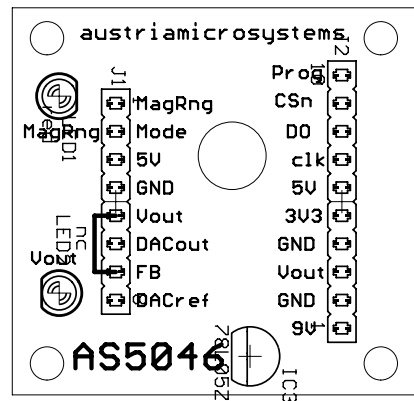
For programming the AS5046, 3 digital signals are required: CSn, Prog and CLK (see datasheet). For permanent writing, VPROG must be elevated to 7.5V during the programming cycle. For immediate programming, this PCB can be connected directly to the AS5046 demo board (available separately), where all the programming timings are generated by the onboard microcontroller.

**AS5046 Adapter PCB Layout and Component Placement:**

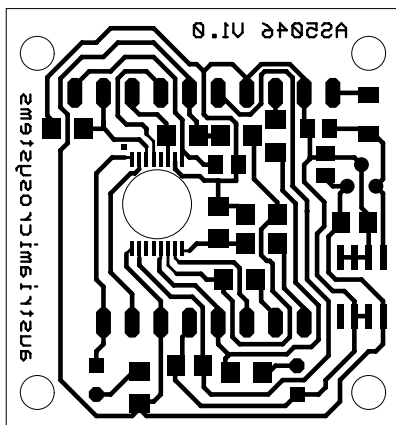
The PCB has several connection options. All required pins are accessible via the two 100mil- connectors J1 and J2. These connectors are 600mil apart, which allows them to be soldered to a wide 16-pin DIL IC socket for easier access or ribbon cable connection. Furthermore, J2 (pins 3...9) fit to the AS5046 demo board and allow this PCB to be used as external encoder.

The hole in the PCB underneath the chip allows centering of a 6mm diameter magnet.

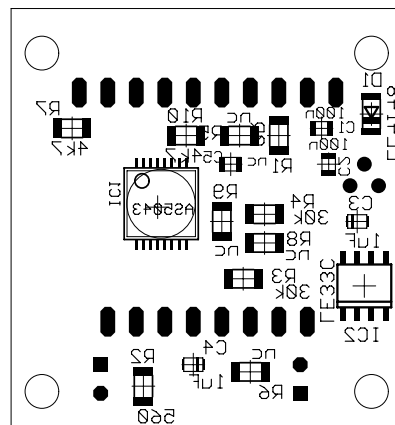
A Vout Led and voltage regulators are optional. Minimum required components are C4 (1µF) and the CSN pull-down R7 (0...4k7).



AS5046 Adapter Board: Top View



Layout: Bottom View



Layout: Bottom Components

### AS5046 Adapter PCB Dimensions:

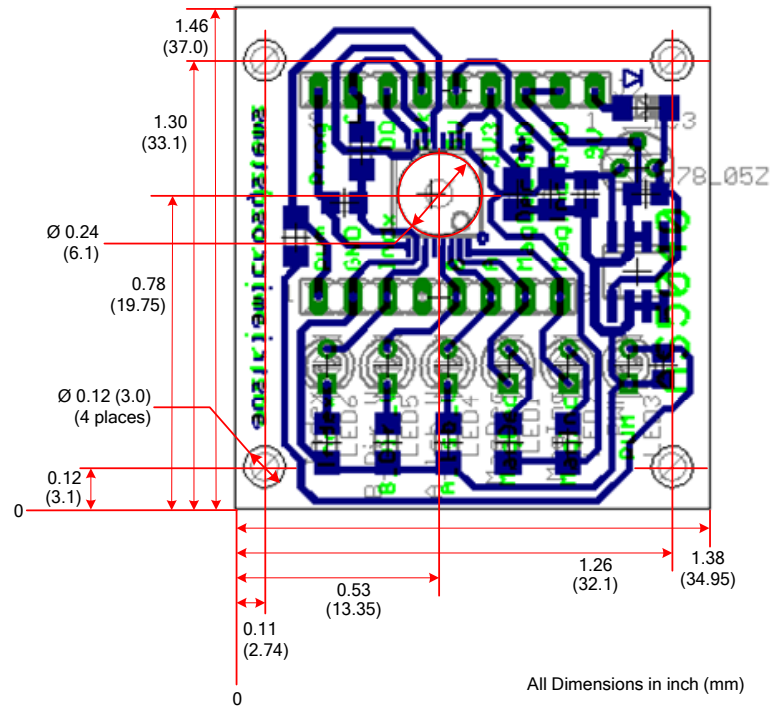


Figure 7: AS5046 adapter board dimensions

## 7 Supporting Tools

austriamicrosystems provides the following tools for developments using the AS5046 rotary encoder IC:

AS5046 Demoboard (see Figure 8)

AS5046 Demoboard Operation Manual

AS5046 Demoboard Software

AS5046 Adapter PCB (see **Error! Reference source not found.**)

AS5000 Encoder Software Development Kit (SDK)

These supporting tools are available at local distributors

[http://www.austriamicrosystems.com/06contactcenter/sales\\_start.htm](http://www.austriamicrosystems.com/06contactcenter/sales_start.htm)

or can be ordered online:

<https://shop.austriamicrosystems.com/>

## 8 AS5046 Demoboard

The AS5046 Demoboard is a complete rotary encoder system with built-in microcontroller, USB interface, 4-digit 7-segment display and a LED displaying the magnitude range.

It also supports external AS5046 applications, such as the AS5046 adapter PCB or in-system AS5046 customer applications that can be connected to the demoboard and displayed, modified and permanently programmed using the AS5046 Demoboard Software.

The AS5046 demoboard can be used in several ways:

### 8.1.1 As standalone unit supplied by a 9V-battery

Connect a 7.5V...12V supply to pins "GND" and "+9V" at the right side of the board. No other connections are required

### 8.1.2 As standalone unit supplied by an USB port

Connect the demoboard to a PC using a USB cable (included in demoboard shipment). The board is supplied by the 5V supply of the USB port. No other connections are required

### 8.1.3 As input device for the AS5046 demoboard software

This configuration uses the same hardware connection as 8.1.2, but additionally the AS5046 demoboard software is running. All indicators on the demoboard will be displayed on the PC screen as well.

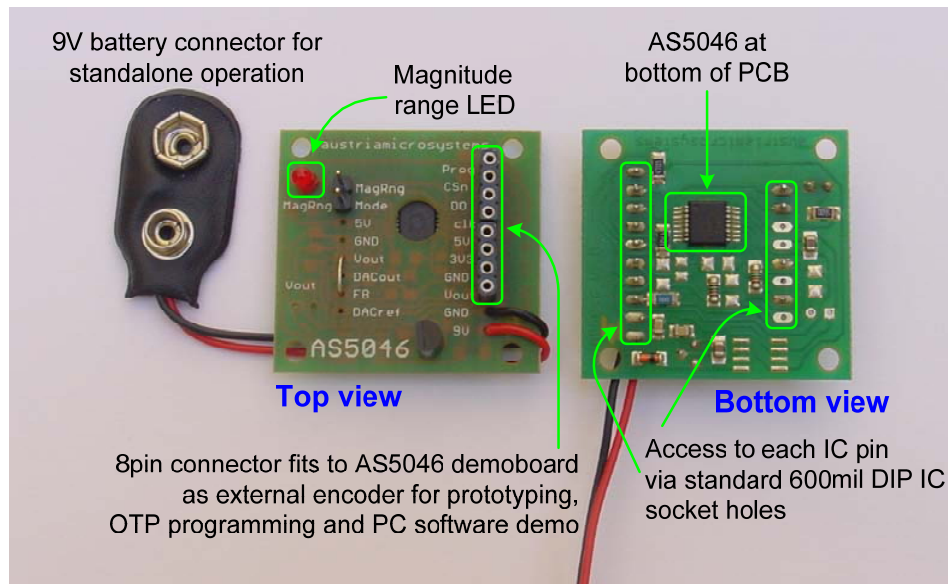


Figure 8: AS5046 demoboard and adapter PCB

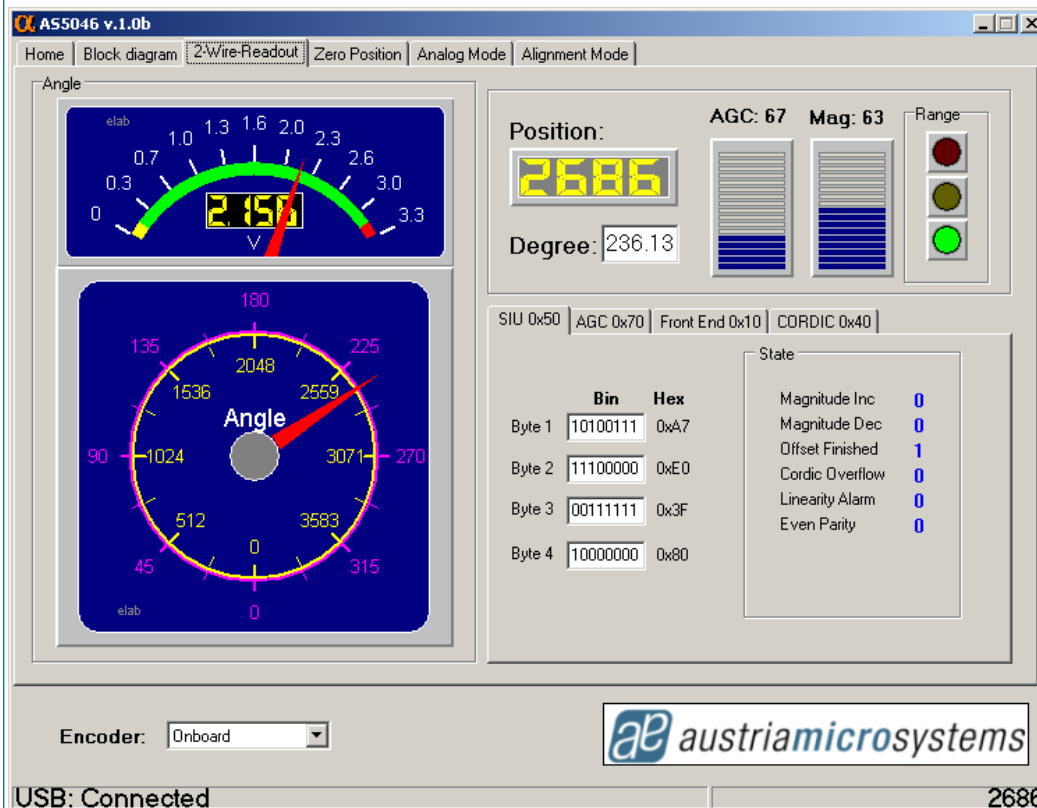
## 9 AS5046 Demoboard Software

The AS5046 Demoboard Software can be downloaded for free from the Internet at:

[http://www.austriamicrosystems.com/03products/products\\_detail/AS5046/download\\_AS5046.htm?#software](http://www.austriamicrosystems.com/03products/products_detail/AS5046/download_AS5046.htm?#software)

It has several indicators and extra features, such as:

- Displaying the absolute angle as 12bit-word (0...4095), as absolute degrees (0° ...360°) and as rotary dial
- Displaying the analog voltage output
- Displaying the status and diagnostic bits of the AS5046
- Displaying the value of the magnitude register
- Displaying the value of the AGC register
- Direct access and configuration of the Hall Elements (Front Ends)
- Direct access to the 12-bit sampled Sin/Cos values (CORDIC)
- Programming the zero position (OTP)
- Programming clockwise or counterclockwise operation (OTP)
- Programming the different analog output modes (OTP)
- Putting the AS5046 in alignment mode to aid centering the magnet over the IC.



Further information on the AS5046 Demoboard Software is available in the AS5046 Demoboard Operation Manual (see: 7 Supporting Tools)

### 9.1 Connecting the AS5046 Adapter PCB to the Demoboard

The AS5046 Adapter PCB is intended as a standalone device that allows easy and quick testing of the AS5046 without the need of having to make your own PCB.

It allows access to each IC pin via a standard 100mil pitch, 600mil Dual-In-Line connector, has LEDs on all digital outputs and comes with an onboard 5V linear voltage regulator (78L05) and a battery clip to supply the board from a 9V battery.

The 8-pin female connector is designed to fit directly onto the AS5046 Demoboard and use the Adapter PCB as external encoder (software setting: Encoder = external).



The demoboard however, runs at 3.3V supply voltage. The adapter PCB is configured for 5V supply voltage. Connecting both boards without modifications will not harm any of the boards, but may lead to data transmission errors due to the different digital levels, especially when an extension cable is used between demoboard and Adapter PCB.

If you use the Adapter PCB as external encoder for the AS5046 demoboard with an extension cable or experience data transmission errors, it is requested to configure the adapter PCB for 3.3V supply voltage.

#### 9.1.1 Modifications to operate the adapter board at 3.3V

Perform the following modifications:

- disconnect the 5V supply between demoboard and adapter PCB: remove or cut off pin "+5VUSB" at the bottom of the AS5046 demoboard
- connect pins "3V3" and "5V" on the adapter PCB. Ideally, connect the pins right at the bottom of the 7pin female connector with a piece of wire or solder joint.
- you may also remove the 78L05 voltage regulator from the Adapter PCB to prevent accidental damage of the IC when an input voltage is applied to the regulator (and the 5V output is fed to the VDD3V3 supply pin)

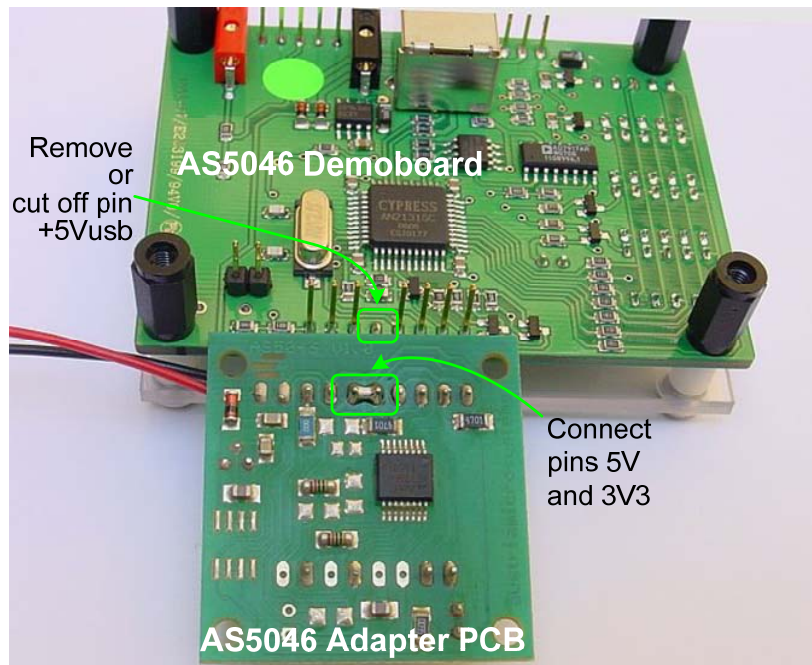


Figure 9: Configuring the adapter PCB for 3.3V operation (see Figure 10)

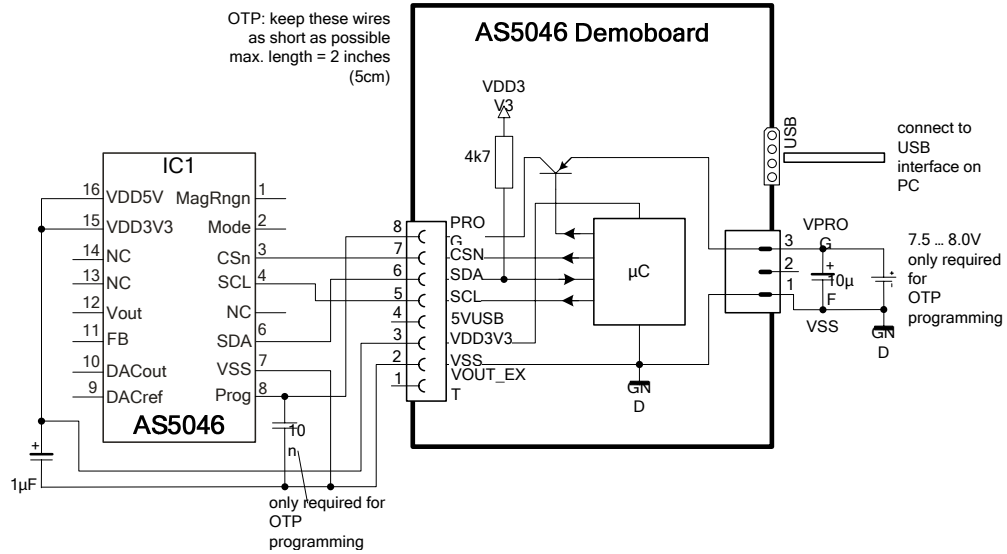


Figure 10: Connecting an external AS5046 application to the demoboard (see Figure 9)

*\* If longer cables are used, a pull-down resistor at the DO line of 22k - 56k Ohms is recommended to discharge the signal between data transmissions and no static voltage is built up.*

## 9.2 Reading the Adapter PCB with the AS5046 Demoboard Software:

Further information on the AS5046 Demoboard Software is available in the AS5046 Demoboard Operation Manual (see 7 Supporting Tools)

The AS5046 Adapter PCB can be read as "external encoder" in the same way as the internal encoder. Switching from internal to external encoder can be done on the bottom left corner of the demoboard software screen: Encoder = onboard / external. Additionally, when Encoder = external is selected, the buttons "Permanent write" and "Read" are enabled in the "Zero Position" and "Incremental Mode" screens to allow OTP programming of the external encoder

### Changing the Zero Position:

The programming options zero position and CCW operation can be modified at any time during normal operation. Permanently programming these registers will set the default setting after power-up. Programmed settings can again be modified during normal operation but will be reset to default when the power supply is disconnected.

### OTP programming of the external AS5046 Encoder:

To program the external AS5046 encoder, a programming voltage of 7.5 to 8V DC (130mA) must be applied to pins Vzapp and GND of the 3-pin connector at the right hand side of the demoboard. A 10 $\mu$ F buffer cap is recommended for this voltage (see Figure 10).

Programming is not recommended with long wires between demoboard and external encoder, as the inductance of the cable may generate high voltage spikes, that can cause wrong programming or even harm the IC. The maximum wire length between the demoboard connector and the PROG pin of the external encoder should be 50mm (2"). Additionally, a 10nF ceramic capacitor should be connected close to pin PROG and VSS.

An OTP (one time programming) cycle is automatically initiated, when button "Permanent write" is pressed. The default (non-programmed) logic state is "0", consequently the programmed logic state is "1". It is possible to write "1"s into the OTP register at subsequent programming cycles. However, a programmed "1" cannot be cleared any more after programming.

Note that the chip will not be programmed, as long as no programming voltage is applied to Vzapp, although the software will issue a warning message that the chip will be permanently programmed.

## 10 Contact

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## 11 Revision History

Revision	Date	Description
1.0	16-May-2007	Creation

## 12 Copyright

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