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# 1 General Overview

The AS5X40 is a contactless magnetic rotary encoder for accurate angular measurement over a full turn of 360°. It is a system-on-chip, combining integrated Hall elements, analog front end and digital signal processing in a single device.
To measure the angle, only a simple two-pole magnet, rotating over the center of the chip, is required. The magnet may be placed above or below the IC.
The absolute angle measurement provides instant indication of the magnet's angular position with a resolution of 0.35° = 1024 positions per revolution (AS5X40). This digital data is available as a serial bit stream and as a PWM signal.
Furthermore, a user-programmable incremental output is available, making the chip suitable for replacement of various optical encoders.
An internal voltage regulator allows the AS5X40 to operate at either 3.3 V or 5 V supplies.

# 2 The AS5X40 Demoboard

The AS5X40 demoboard is a complete rotary encoder system with built-in microcontroller, USB interface, graphical LCD display, incremental indicators, commutation indicators and PWM output LED.
The board is USB powered or externally supplied with a 9V battery for standalone operation.

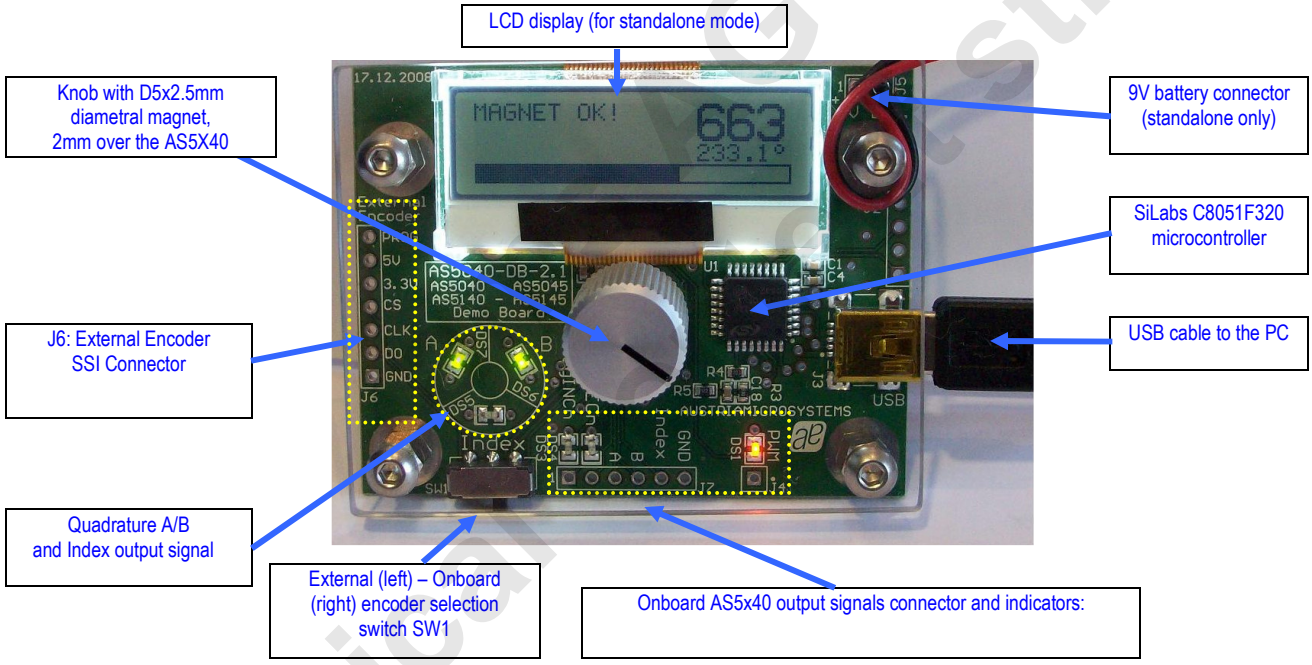


**Figure 1: AS5X40 Demoboard hardware with mounted magnet knob**

# 3 Operating the AS5X40 Demoboard

The AS5X40 demoboard can be used in several ways:

- **As standalone unit supplied by a 9V battery**

Connect a 9V battery to the battery connector on the top right side of the board. No other connections are required.

- **As standalone unit supplied by an USB port**

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

- **As input device for the AS5000 Programmer GUI software**

This configuration uses the same USB hardware connection as above, but additionally the AS5000 Programmer GUI software is running. The LCD display will be turned off and the Angle/Multiturn/AGC will be displayed on the PC screen. Some extra features as pole pair, zero position or AGC programming can be achieved. The parameters will not be permanently programmed. All the parameters will be lost when the demoboard is shut down. For a permanent device programming, the "AS5000 Programmer" hardware should be used.

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## 3.1 Hardware Indicators and Connectors

### 3.1.1 Graphic LCD display

The LCD display shows the realtime absolute angle position of the magnet with a resolution of 0.35° = 1024 positions per revolution (AS5X40) and the absolute value of the angle.
Turning the knob clockwise will increase the angle value until 359,6 then 0.

The magnet status indicator is related to the magnet position. If the magnet is too close to the encoder, “Magnet too close” will be displayed. If the magnet is too far away from the encoder, “Magnet out of range” will be displayed.

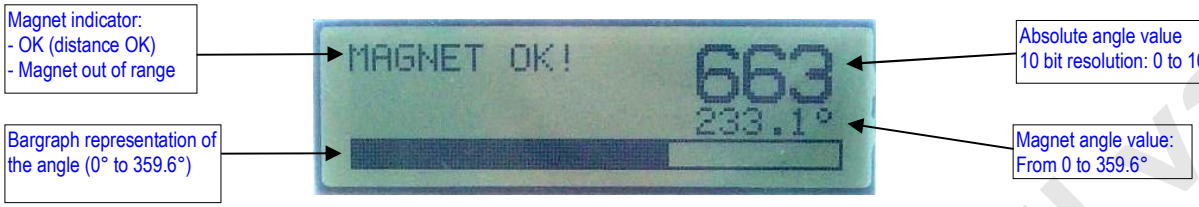


**Figure 2: LCD display in standalone mode (9V battery or USB powered without GUI)**

### 3.1.2 PWM LED

This LED is connected to the PWM output of the AS5X40. The PWM output is a pulse width that is proportional to the angle of the magnet.
The pulse width varies from 1µs to 1024µs with a repetition rate of 1.0 kHz. Viewing the PWM signal on the LED results in brightness, that is proportional to the angle of the magnet. When the angle of the magnet is at 0°, the LED is almost dark, as it is 1µs on and 1023µs off. Turning the knob clockwise towards higher angles increases the brightness of the PWM LED, since the ON-pulse becomes longer and the OFF-pulse becomes shorter.
Likewise, the PWM output can be used as an analog output proportional to the angle, when the PWM signal is filtered by a RC (or active) lowpass filter.
The PWM signal (0 ~ 3V3) can be directly taken from the connector J4.

### 3.1.3 Incremental quadrature AB-Index LED

The phase shift between channel A and B indicates the direction of the magnet movement. Channel A leads channel B at a clockwise rotation of the magnet (top view) by 90 electrical degrees. Channel B leads channel A at a counter clockwise rotation.
One Index pulse (3V3) is generated at the angle 0 (see AS5X40 datasheet Figure 9)

The AB-Index LEDs are directly connected to the A B Index outputs of the AS5X40. These quadrature signals (0 – 3V3) are available on connector J7.

### 3.1.4 MagINCn and MagDECn

MagINCn and MagDECn are the magnetic field change indicators (magnetic field strength increase or decrease through variation of the distance between the magnet and the device).

These outputs can be used to detect the valid magnetic field range. If both indicators lit simultaneously (MagINCn = 0 and MagDECn = 0), the magnet is out of range, the airgap between the encoder and the magnet is too high or too low. In that case, “Magnet out of range” will be displayed on the LCD display.

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### 3.1.5 Encoder selection switch

The switch SW1 selects the encoder which communicates with the microcontroller through the SSI bus:

1. Right position (default): Onboard AS5040/AS5140

2. Left Position: External AS5040/AS5140 connected on J6
   The signals of the synchronous serial interface (DO, CLK, CSn, PROG) and the power supply (3.3V, GND) of an external device can be connected directly to J6. In this configuration, the data of the serial interface are displayed on the GUI or the LCD.

- In standalone mode, regardless to the demoboard type (AS5040 or AS5140), AS5040 and AS5140 can be attached to J6 and evaluated. See figure 3.
- If the GUI is used for operation, additional devices AS5043, AS5143, AS5045 and AS5145 can be connected to J6 and evaluated. In that case, the correct encoder must be selected instead of "Autoselect" in the Device list of the PC software, see chapter **Error! Reference source not found.** figure 4.

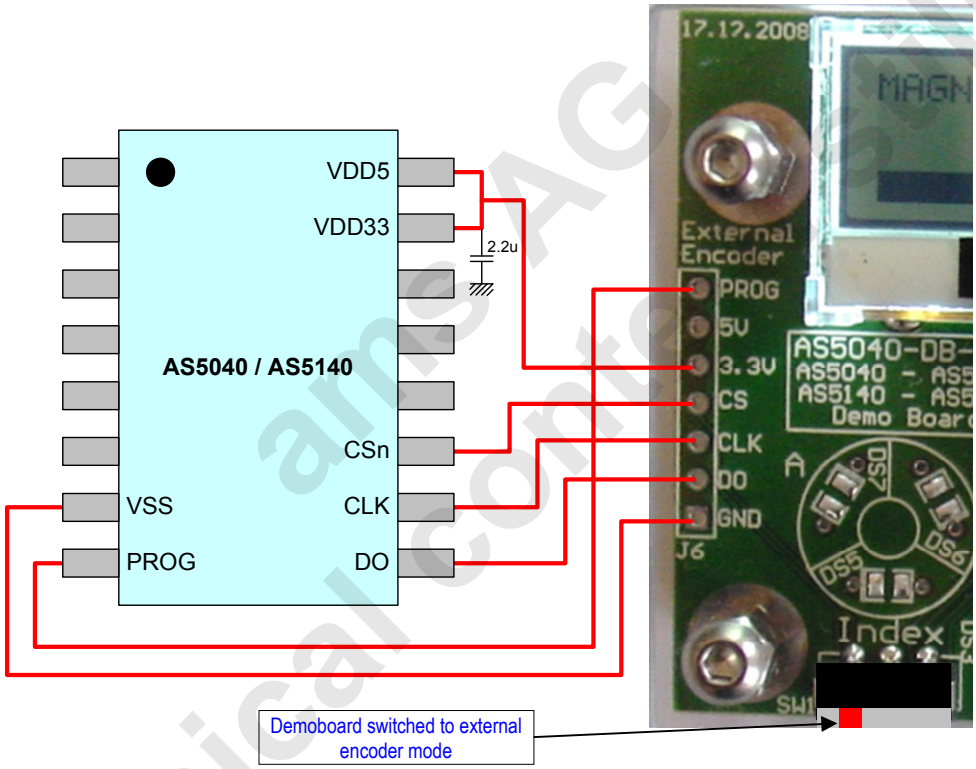


**Figure 3: external AS5040/AS5140 connection to the demoboard**

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# 4 AS5000 Programmer GUI software

## 4.1 Installing the GUI on the PC

The preliminary software is developed for a Microsoft Windows XP operating system with Service Pack 2. In addition the dotnet (.NET) framework version 2.0 or more must be installed on the PC. This package can be downloaded free of charge from the Microsoft webpage:
http://www.microsoft.com/downloads/details.aspx?FamilyID=0856eacb-4362-4b0d-8edd-aab15c5e04f5&displaylang=en

Following Procedure is recommended before starting the GUI:

1. check on your PC if Service Pack 2 is installed
2. install the mentioned .NET package to your computer
3. execute setup.exe
4. Finally start the GUI using the shortcut in the start menu or desktop.

## 4.2 The Home tab

Figure 4 shows the main window of the GUI. On the top left corner, board information's as firmware (FW) version and demoboard name declaration can be found.
By default the GUI is in the auto detection mode. Any connected austriamicrosystems demoboard and programming tool will be automatically detected and displayed in the right top corner. The GUI is divided into three main sections HOME, SSI and OTP.

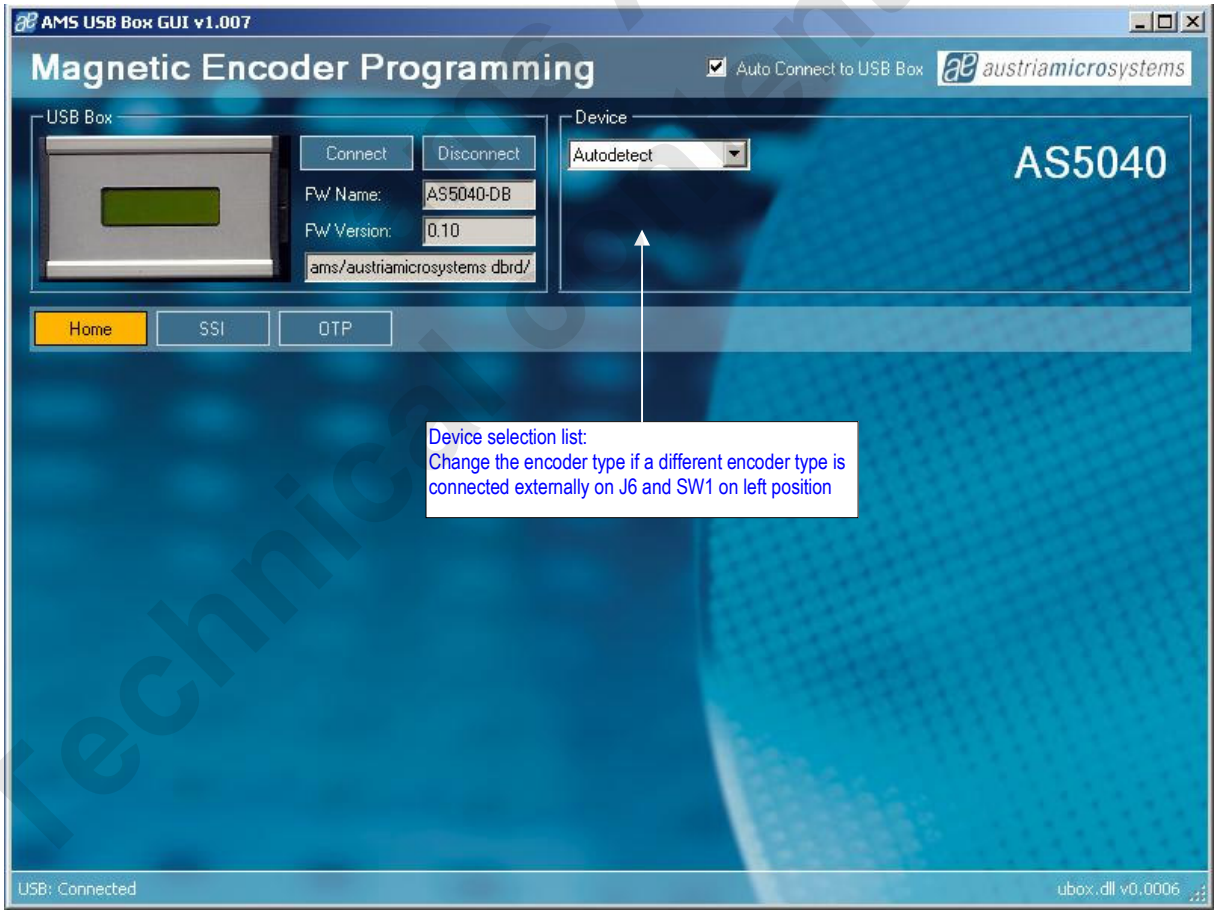


**Figure 4: AS5000 GUI detected the AS5040 Demoboard**

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## 4.3 The SSI tab

This mode displays in realtime the angle & absolute value, status bits and magnet range status.

By selecting the SSI (serial protocol for AS5040, AS5140, AS5043, AS5143, AS5045, AS5145) tab, the information of the angular position and the status bits appears. See figure 5.

**Figure 5: SSI tab, allows access to the AS5X40 registers from the serial bus**

**Value** is the Angle data [D9:D0] from the RD_ANGLE (Read Angle) serial command. This value is continuously updated.

The **Zero Pos.** value represents the Zero Position register. By clicking on the Set button, the actual angle "Value" is written into the Zero Position register. Clicking on Reset writes the value 0 to the Zero Position register.

The **Magnetic Range Warning** is continuously read from the RD_ANGLE serial command.

- Green lamp: Magnet in range
- Orange lamp: Magnet too far or too close. MagINC and MagDEC are set.

The **Status bits information** are taken from the serial stream.

The **Read Interval** can be modified from 10 ms (fastest) to 1 s (slowest).

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## 4.4 The OTP tab

The OTP tab is normally used for the AS5000 programmer, but the OTP bits can be changed on the AS5X40 demoboard as well.

Options like Zero Position, Pulses per revolution and Incremental Mode Selection can be changed by selecting the function in *"Fields"*, then changing the parameter in *"Options for the selected field"* or directly the decimal value of this parameter in *"Value"*.

Each time a field's value has been changed, the corresponding OTP bits will be automatically checked in the right window.
The button Write should be clicked to write the parameter into the AS5X40.
The Read button reads back the OTP register, and updates the "Field" parameter as well as the OTP bits window.

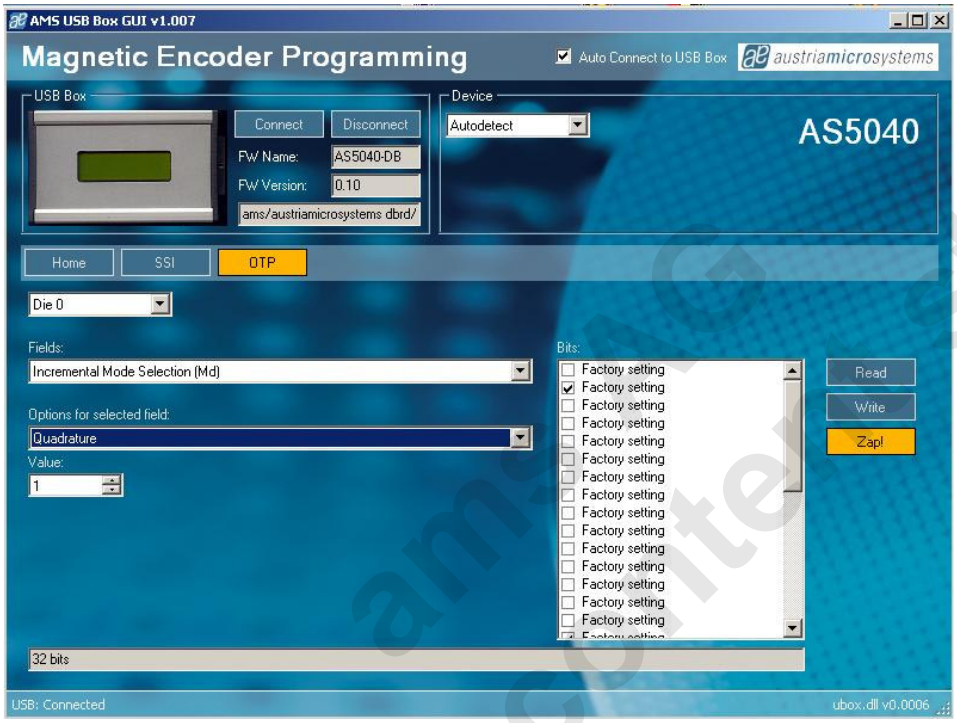


**Figure 6: OTP tab**

**Field Zero Position:** To zero position value, like on the SSI tab. The zero position value can be changed by checking the Z[0:9] bits, or changing the Value field with a decimal number.

**Field Pulses per Revolution:** (The resolution can be reduced from 10bit down to 9, 8, 7 bit, by using the divider setting bits Div1 and Div0)

- 0: 256 ppr (10 bit)
- 1: 128 ppr ( 9 bit)
- 2: 64 ppr ( 8 bit)
- 3: 32 ppr ( 7 bit)

**Field Incremental Mode Selection:** To change the Incremental AB-Index output to:

- 0: Default
- 1: Quadrature
- 2: Step Dir
- 3: Commutation

Note that the Zap! button is used for the AS5000 Programmer only and has no effect on the AS5X40 Demoboard.

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# 5 AS5X40 Demoboard, Schematics, Blockdiagramm

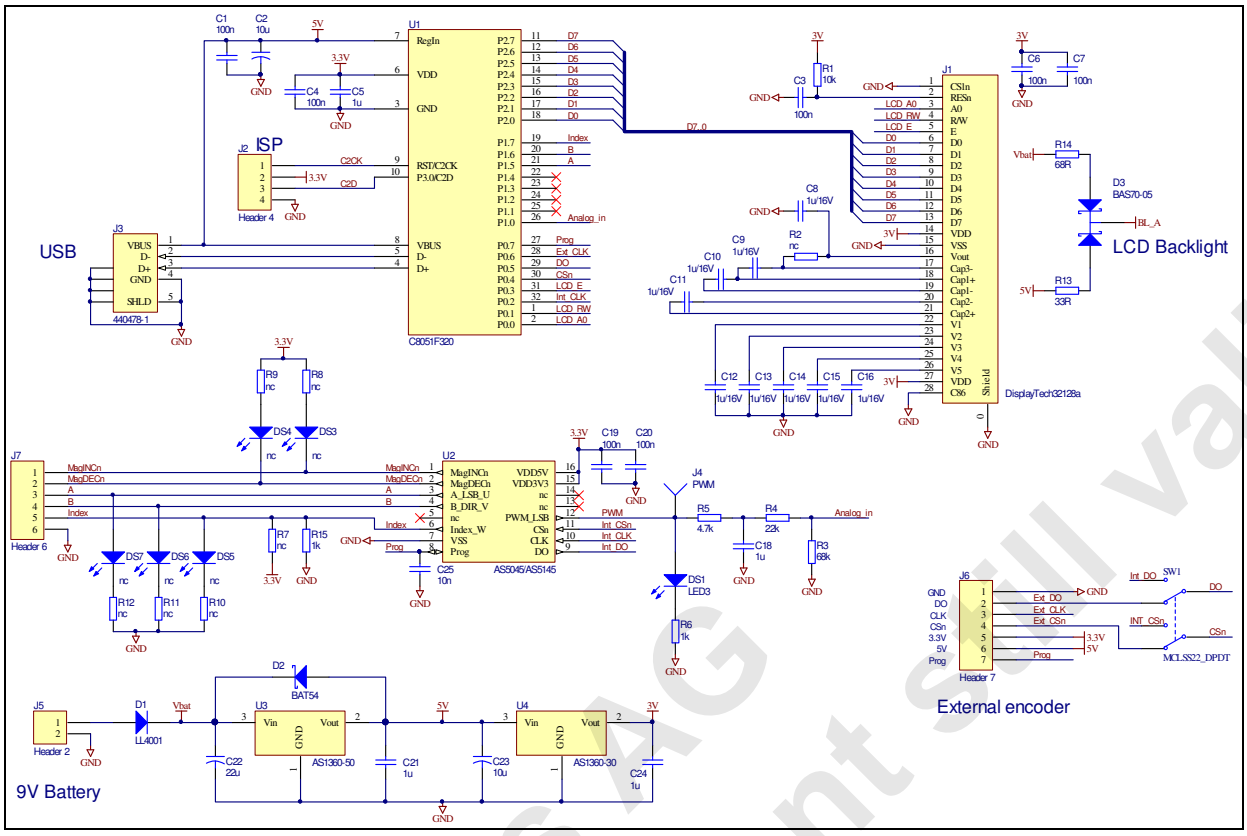


Figure 7: AS5x40 Demoboard schematics

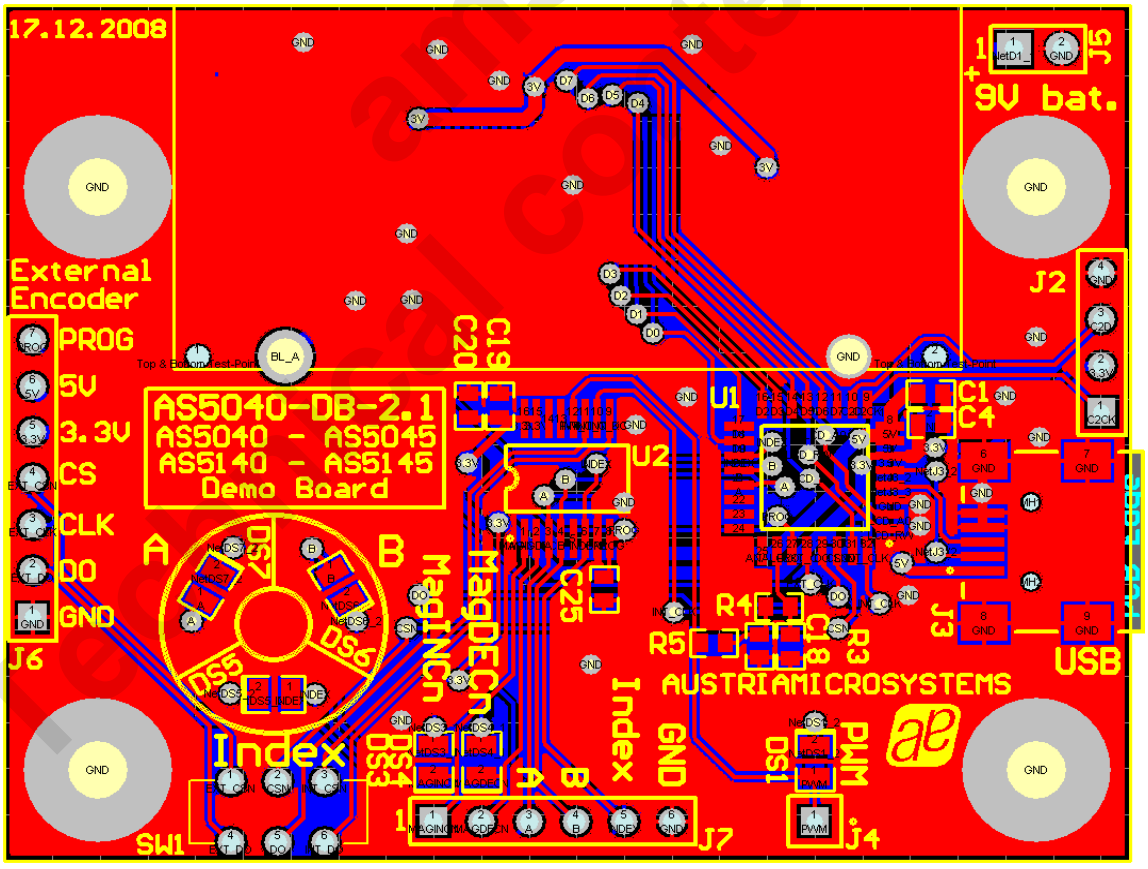


Figure 4: AS5x40 Demoboard PCB Layout

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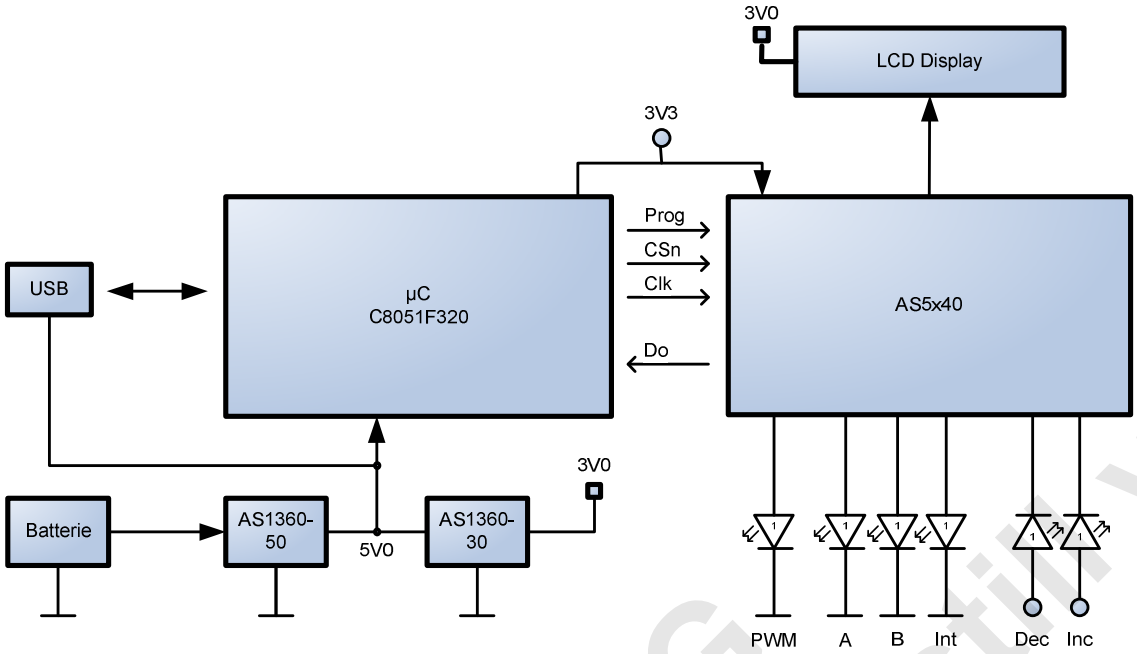


**Figure 9: AS5x40 Blockdiagramm**

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## Revision History

| Revision | Date | Description | |
|---|---|---|---|
| R1.0 | March.16, 2009 | First version | |
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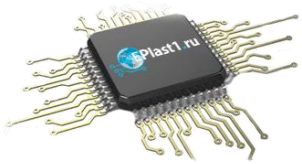


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