

Figure 1: AS5040 with magnet

1 Abstract

This application note describes the necessary precautions that should be observed when transmitting serial data from a remote AS5040 sensor chip to a microcontroller. As an example, the AS5040 adapter PCB is used as remote sensor and the AS5040 demoboard is used as receiving controller.

Before continuing to read this document, you should be familiar with the principal operation of the AS5040 magnetic encoder IC, the AS5040 demoboard and AS5040 adapter PCB. The respective documents may be downloaded from the austriamicrosystems website and the demoboards may be ordered from local distributors. For further reference, see chapter 8: Supporting Tools at the end of this document.

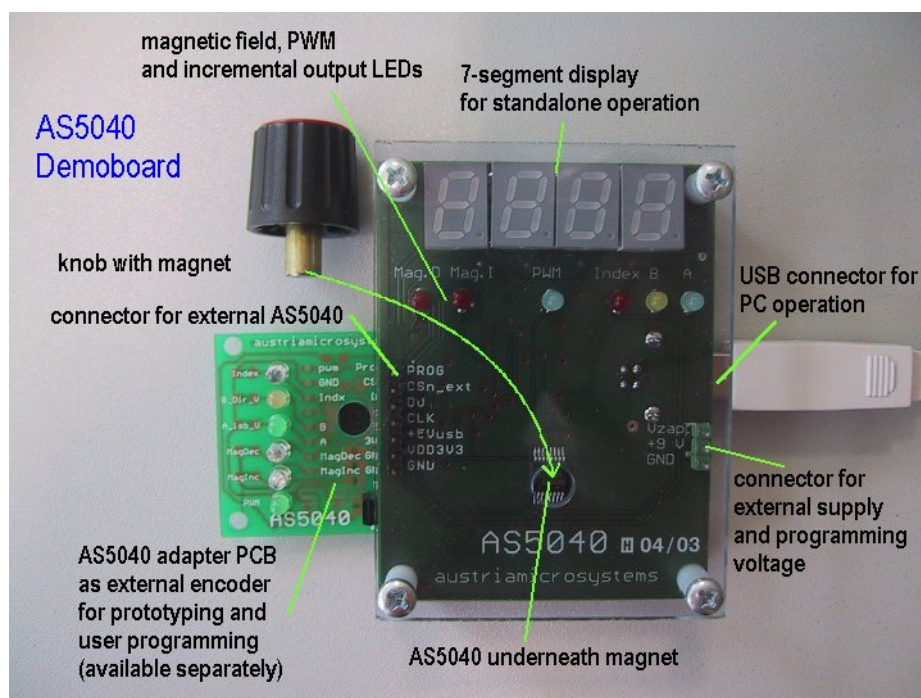


Figure 2: AS5040 demoboard (receiving unit) and AS5040 adapter PCB (sending unit)

2 Circuit Diagram

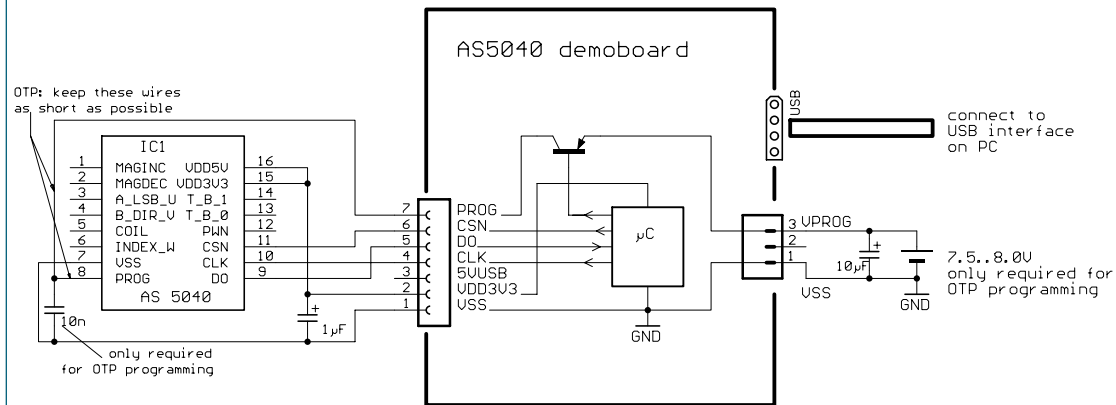


Figure 3: Connection diagram for an external AS5040 encoder

Figure 3 shows the connection of an external AS5040 for serial data transmission and OTP programming. Note that VDD5V and VDD3V3 are tied together, as the controller on the demoboard is supplied by 3.3V. For 5V microcontrollers, these two pins must be separated. VDD5V must be supplied by 5V and VDD3V3 must be buffered by a 1µF capacitor (see Figure 4).

2.1 Serial Data Transmission

For serial data transmission, the following signals are required:

- CSn (pin 11): Chip Select Schmitt-Trigger input: initiates data transfer
- CLK (pin 10): Clock Schmitt-Trigger input: used to shift data out of DO pin
- DO (pin 9): 3-state digital Data Output: provides serial data of 10bit angle and status information
- VSS (pin7): Common Ground

2.1.1 Supply Voltage

It is important to adjust the supply voltage of the external encoder such that it matches the supply voltage of the receiving controller. The proper connections for 3.3V and 5V operation are shown in Figure 4.

2.1.2 OTP Programming

Pin Prog is used for OTP programming, as data input in Daisy Chain mode and to switch the AS5040 to alignment mode. For normal data transmission of a single device, it is not used.

Programming the AS5040 is recommended only with a short cable (1 – 2 inches, see Figure 3) between the switching transistor (included in the demoboard) and pin Prog, as long wires may induce high induction voltages caused by the programming current spikes during OTP programming.

The circuit diagram in Figure 3 shows the Prog pin connected to the demoboard to allow OTP programming of the external encoder. If the external encoder is not to be programmed, this extra connection is not required and pin Prog should be connected to VSS.

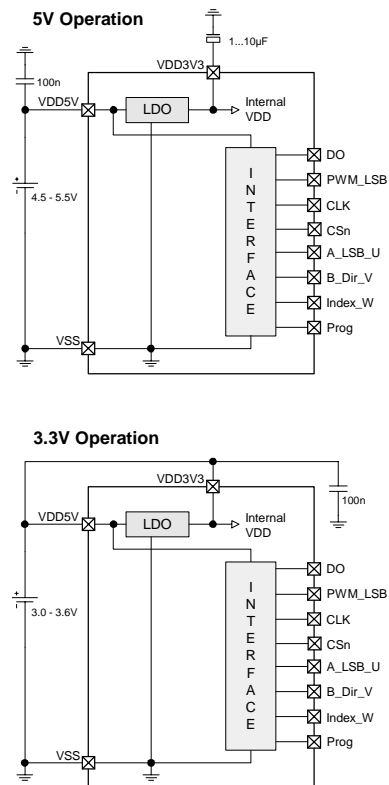


Figure 4: Connections for 5V / 3.3V supply voltages

3 Pin Configuration and Pin Description

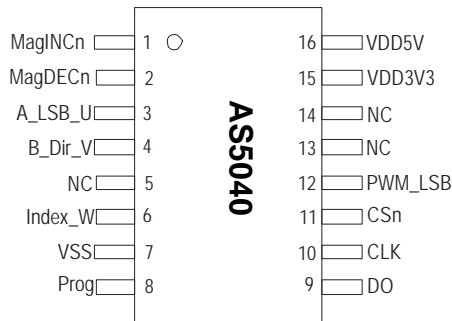


Figure 5: Pin configuration SSOP16

Pin	Symbol	Type	Description
1	MagINCn	DO_OD	Magnet Field Magnitude IN crease; active low, indicates a distance reduction between the magnet and the device surface.
2	MagDECn	DO_OD	Magnet Field Magnitude DE crease; active low, indicates a distance increase between the device and the magnet.
3	A_LSB_U	DO	<i>Mode1</i> : Quadrature A channel <i>Mode2</i> : Least Significant Bit <i>Mode3</i> : U signal (phase1)
4	B_Dir_V	DO	<i>Mode1</i> : Quadrature B channel quarter period shift to channel A. <i>Mode2</i> : Direction of Rotation <i>Mode3</i> : V signal (phase2)
5	NC	-	Must be left unconnected
6	Index_W	DO	<i>Mode1 and Mode2</i> : Index signal indicates the absolute zero position <i>Mode3</i> : W signal (phase3)
7	VSS	S	Negative Supply Voltage (GND)
8	Prog	DI_PD	Programming and Data Input for Mode configuration, incremental resolution setting, Zero-Position Programming and Daisy Chain mode configuration. Internal pull-down resistor (~74kΩ). Connect to VSS if not used
9	DO	DO_T	Data Output of Synchronous Serial Interface
10	CLK	DI, ST	Clock Input of Synchronous Serial Interface; Schmitt-Trigger input
11	CSn	DI_PU, ST	Chip Select, active low; Schmitt-Trigger input, internal pull-up resistor (~50kΩ)
12	PWM_LSB	DO	Pulse Width Modulation of approx. 1kHz; LSB in <i>Mode3</i>
13	NC	-	Must be left unconnected
14	NC	-	Must be left unconnected
15	VDD3V3	S	3V-Regulator Output
16	VDD5V	S	Positive Supply Voltage 5 V

Table 1: Pin description

4 Timing Diagrams

4.1 Direct Connection of External Encoder

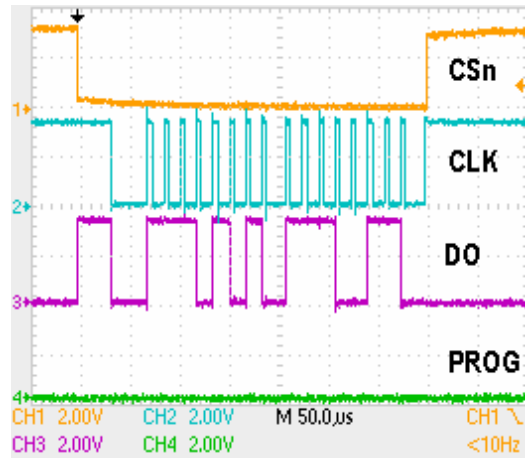


Figure 6: Data transmission signals between external encoder and demoboard without cable

Figure 6 shows a snapshot of the signals CSn, CLK, DO and Prog during data transfer between AS5040 adapter PCB and AS5040 demoboard with a direct connection (no extension cable) as shown in Figure 2. Pin Prog is connected to the demoboard as shown in Figure 3. The output of signal DO will vary, depending on the angle of the magnet.

4.2 Connection of External Encoder over Long Cables

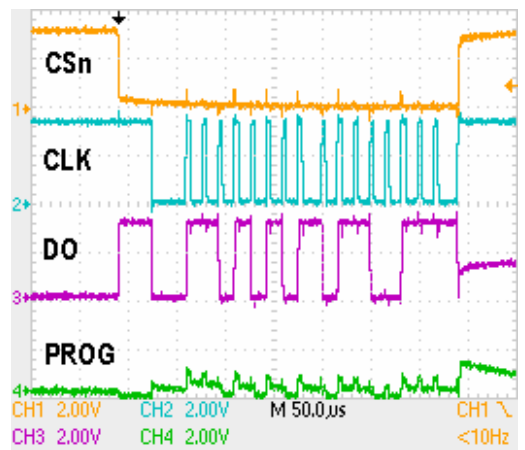


Figure 7: Data transmission signals between external encoder and demoboard with 82ft cable

Figure 7 shows the same signals as Figure 6, but this time with a 82ft (25m) extension cable between demoboard and adapter PCB. No other modifications were done at this time. Data transmission was still possible without errors.

Note: The larger spikes on signals CSn and especially on Prog due to cross-coupling in the cable.

Another noticeable difference in the signals is the higher voltage at DO when CSn switches back to High and forces DO to tri-state after data transmission is completed.

With DO at tri-state and a high impedance digital input at the microcontroller, the charge on the cable capacitance can only discharge slowly (see Figure 8 below)

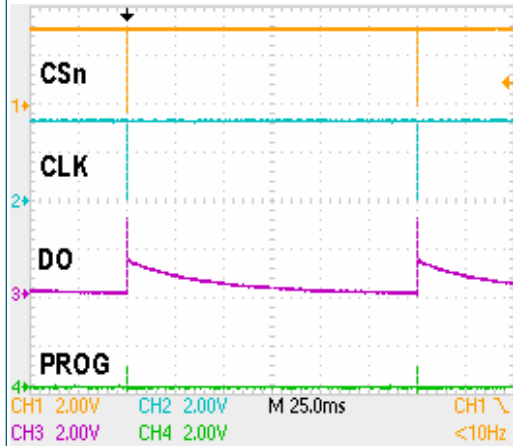


Figure 8: Same as Figure 7, but with compressed time scale

On the compressed time scale (Figure 8) the slow discharge of signal DO can be clearly seen.

Since the demoboard software only takes one sample about every 150ms, there is enough time for the signal to discharge. That is why it appears discharged at the beginning of each subsequent sampling cycle.

Although this slow discharge does not influence the data transmission at all, this high impedance path should be avoided by connecting a pull-down resistor from DO to VSS.

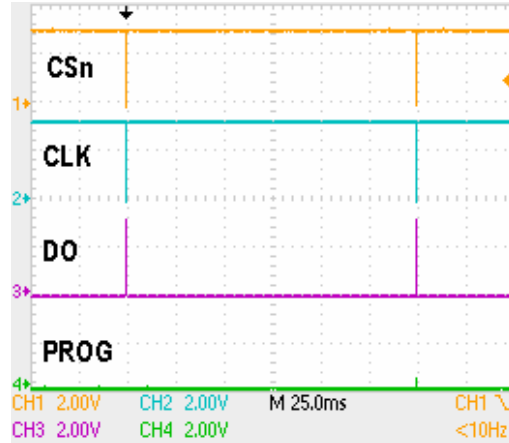


Figure 9: Data transmission signals with pull-down resistor at DO

Figure 9 shows the same setup as Figure 8, but with a 22k...56k pull-down resistor at pin DO (see Figure 10). Note that signal DO discharges immediately at the end of each data transmission and no static voltage is built up in the wire between the samples.

4.2.1 OTP Programming over Long Wires

OTP programming is not recommended with long cables between demoboard and external encoder (see 2.1.2), so pin Prog is not used in this application. Although this pin has an internal ~74kΩ pull-down resistor, it should not be left open when long cables are used, as the cross-coupling in the cable may generate unwanted voltages (see Figure 7). To avoid these unwanted signals, pin Prog should not be connected to the demoboard when long extension cables are used. It should rather be connected to VSS.

Note: When several AS5040 devices are connected in Daisy Chain mode, pin Prog of the first device is connected to pin DO of the next device, and so on. The last device in the chain has an unused Prog pin, which should again be connected to VSS.

connect PROG to DO of next AS5040 (daisy-chain) or to VSS if not used

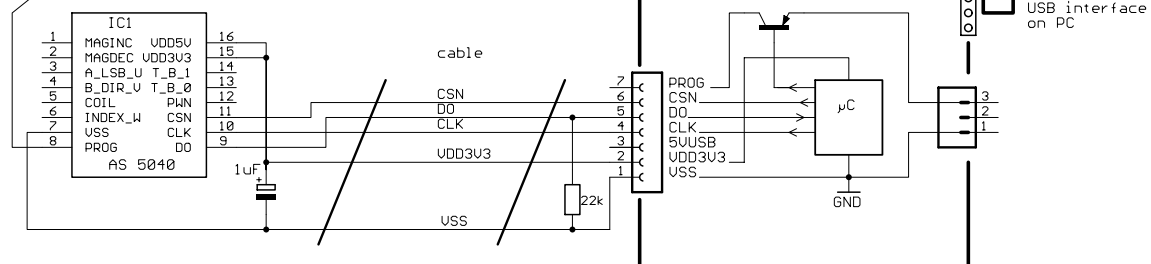


Figure 10: Connection diagram for external AS5040 encoder using long extension cable

5 Shielded or Unshielded Cables?

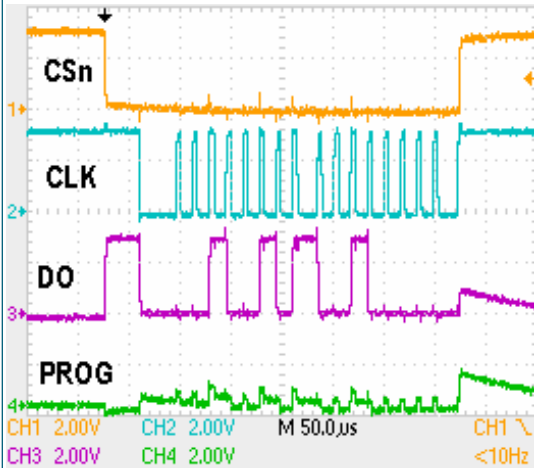


Figure 11: Signal waveforms with unshielded cable

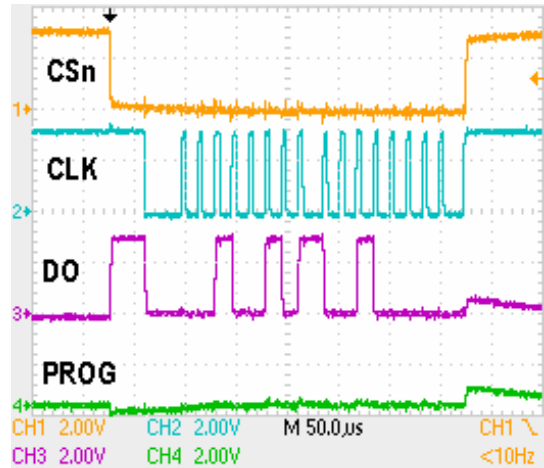


Figure 12: Signal waveforms with shielded cable

While data transmission is certainly possible even with a long unshielded cable, it is recommended to use shielded cables, especially when external EMC noise coupling cannot be avoided. Figure 11 shows the signal waveforms on an external AS5040, connected over a 82ft (25m) unshielded cable, Figure 12 shows the same setup with a shielded cable. The improvement in noise is obvious.

5.1.1 Schmitt-Trigger Inputs

If the external EMC noise is so severe, that it generates additional clock or chip-select pulses, data transmission will eventually be corrupted. In this case, pins CSn and CLK may be filtered individually by a lowpass filter, that removes the EMC spikes on those signals. Since pins CSn and CLK are Schmitt-Trigger inputs, so they do not require a minimum rise/fall-time of the signals and can hence accommodate even slowly rising/falling slopes, as long as the voltage levels are adequate:

V_{inHigh} must be $>0.7 \cdot V_{DD5V}$

V_{inLow} must be $<0.3 \cdot V_{DD5V}$

6 One-Wire Data Transmission

Data transmission over the serial interface requires 3 wires: CSn, CLK, DO and in addition, the common ground VSS. Using the PWM output (pin 12) requires only one wire (besides VSS). The angle information lies in the pulse width of the PWM signal: an angle of 0° results in a pulse width of 1µs. Each step (0.35°) increases the pulse width by 1µs, so the pulse width eventually grows to 1024µs at 359.65°. The pulse repeats every 1025µs (~1ms).

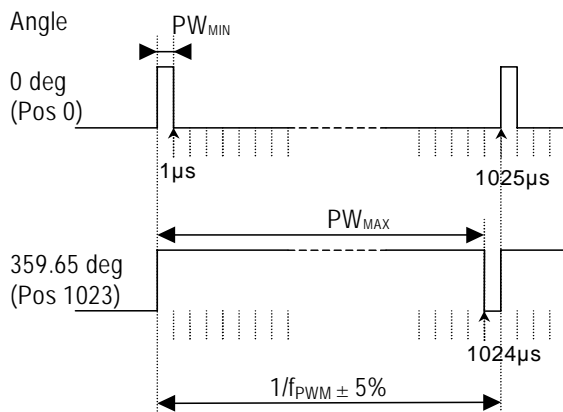


Figure 13: PWM signal waveform

As the angle information lies in the pulse width of the signal and not in the amplitude, this type of data transmission is very robust and insensitive to disturbances. On the receiving side, a timer/counter with minimum 1µs resolution is required.

Evaluating the complete duty cycle (T_{on} and T_{off}) further enhances the reading accuracy, as it cancels the tolerance of the AS5040's internal timer ($\pm 5\%$).

$$Position = \frac{t_{on} \cdot 1025}{(t_{on} + t_{off})} - 1$$

7 Connecting the AS5040 Adapter PCB to the Demoboard

The AS5040 adapter PCB is intended as a standalone device that allows easy and quick testing of the AS5040 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 7-pin female connector is designed to fit directly onto the AS5040 demoboard and use the adapter PCB as external encoder (software setting: encoder = external).

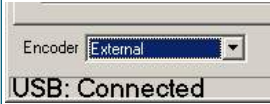


Figure 14: Demoboard software setting (lower left corner of screen)

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.



Figure 15: Configuring the adapter PCB for 3.3V operation

If you use the adapter PCB as external encoder for the AS5040 demoboard with an extension cable or experience data transmission errors, it is recommended to configure the adapter PCB for 3.3V supply voltage.

Perform the following modifications:

- Disconnect the 5V supply between demoboard and adapter PCB: remove or cut off pin "+5VUSB" at the bottom of the AS5040 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)

8 Supporting Tools

austriamicrosystems provides the following tools for developments using the AS5040 rotary encoder IC:

AS5040 Demoboard	AS5040 Adapter PCB Operation Manual
AS5040 Demoboard Operation Manual	AS5040 Daisy Chain Software
AS5040 Demoboard Software	AS5040 Application Notes
AS5040 Adapter PCB	

Documentation and software may be downloaded from the austriamicrosystems website:
http://www.austriamicrosystems.com/03products/products_start.htm

Demoboards and adapter PCBs are available from local distributors
http://www.austriamicrosystems.com/06contactcenter/sales_start.htm
or can be ordered online: http://www.austriamicrosystems.com/03products/request_5040.htm

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9.1 Sales Offices

http://www.austriamicrosystems.com/06contactcenter/sales_start.htm

10 Revision History

Revision	Date	Description
1.1	Oct.27,2005	Modify Figure 1
	Aug.29,2005	Replace Figure 3; change cap on Prog pin
A.00	Nov.25,2004	Initial revision

11 Copyright

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