1 General Description

This document describes the features and operation of the AS5304/-06 Evaluation Kit.
The AS5304 and AS5306 are Hall-sensor based encoder chips suitable for high resolution measurement of linear motion or off-axis rotary motion using multipole magnetic strips or rings.
Both AS5304 and AS5306 are pin-compatible, the main difference is the resolution. The AS5304 has a resolution of 25µm per step, using multi-pole magnets with 2mm pole length and the AS5306 has a resolution of 15µm per step, using multi-pole magnets with 1.2mm pole length.

1.1 Evaluation kit contents

The AS5304/-06 evaluation kit contains the following parts:

- An AS5304/-06-AB adapterboard populated with either an AS5304A or AS5306A chip
- An AS5000-CT LCD counter module
- A plexiglass bar with a multipole magnetic strip, either with 2.0mm or 1.2mm pole length, matching the installed chip
- a fixture to hold the magnetic bar
- a 9V battery

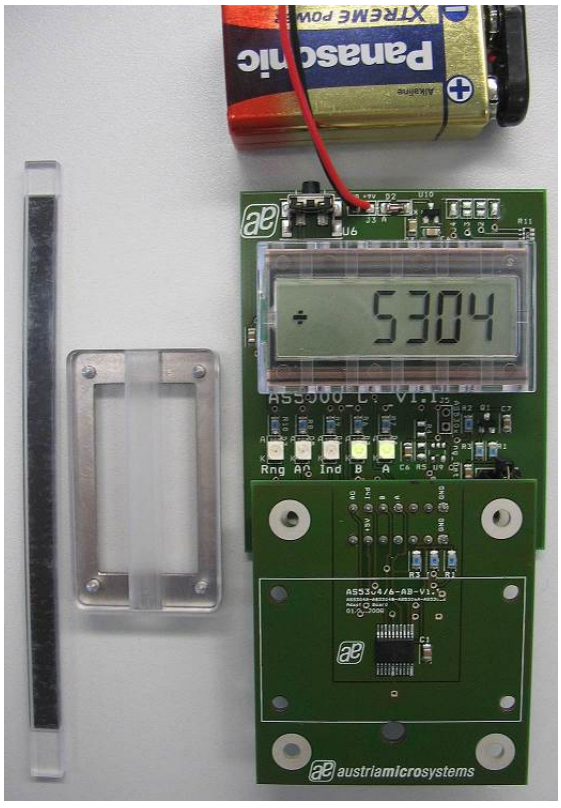


Fig. 1: AS5304 Evaluation Kit with 2.0mm pole length magnet

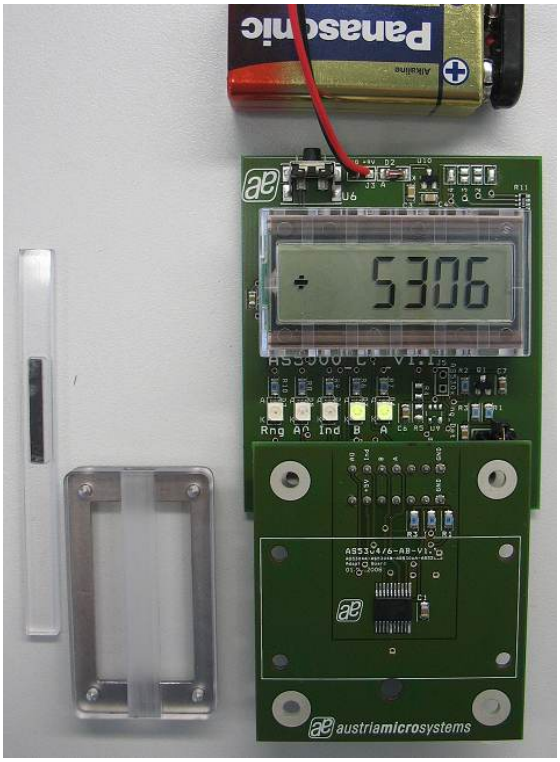
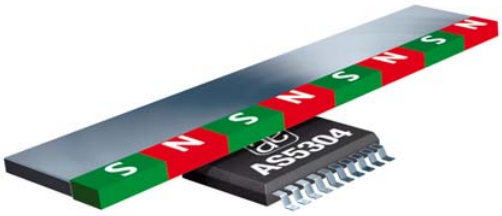


Fig. 2: AS5306 Evaluation Kit with 1.2mm pole length magnet

2 Features of the AS5304/-06 Evaluation Kit

The AS5304A or AS5306A mounted on the adapterboard are located in an exposed area of the PCB to allow the placement of either a fixture containing a sliding multipole magnetic bar over the IC.
Holes in the PCB match with pins on the fixture to hold the magnet strip in place when it is attached to the AS5304/-06 adapterboard.



3 The LCD counter module

The LCD counter module is connected directly to the AS5304/-06 adapterboard. It is used to display the position of the magnetic strip or ring.
The main features of the AS5304/-06CT counter module are:
6-digit 7-Segment LCD display with up/down quadrature counter displaying the incremental steps of the AS5304/-06 A and B outputs.
5 LEDs displaying quadrature A-/B- outputs, Index output and an auxiliary analog/digital output of the AS5304/-06 IC.

Fig. 3 : the counter module with reset button and jumper

The LCD counter module is attached to the AS5304/-06 adapterboard by a 14-pin female connector. The LCD display is a 6-digit 7-segment display with +/- sign. It can be manually reset by pressing the reset button on the top left of the display.
The counter module will count up when the magnet is slid over the IC from left to right and it will count down when the magnet is moved from right to left.

3.1 The index reset jumper

Both AS5304 and AS5306 generate 40 quadrature pulses per polepair, respectively 160 edges = 160 positions before an Index output is generated.

A jumper (J6) “Index_En” on the bottom right corner of the display is used to reset the counter automatically by an Index pulse from the AS5304/-06 if this jumper is set (=default).

Note: if the jumper is set, an index pulse is generated once for every pole pair. This means, once for every 4mm (using the AS5304 adapterboard) or once for every 2.4mm (using the AS5306 adapterboard).

The jumper can be set in three ways (see schematic, Fig. 10: J6):

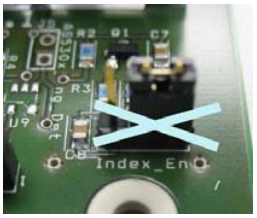
- AC decoupled connection with a 10nF capacitor between index output and reset input (recommended)

In this setting, the counter will count from 0….159 between two index pulses

- Disconnected counter reset input, jumper = open

In this setting, the counter will not be reset by the index pulse. It will continue to count until it is reset manually by the reset button or by a power cycle.

- A direct DC connection between index output and reset input (not recommended).



In this setting, the counter will count from 0…158 rather than from 0….159 between two index pulses
(see description below)

If the jumper is set to direct DC connection, the counter module only counts up to 158. This is due to the reset input of the counter module, which is a static reset: The counter output stays at 0000 while the reset input is held low.
The Index signal coming from the AS5304/-06 is used to reset the counter. However, is slightly delayed with respect to the incremental A and B outputs by the discrete inverter Q1. This leads to the effect that the Reset input of the counter module is still held low during the transition from counts 00 to +01 (or 00 to -01) and keeps the counter reset at 0000 (although the AS5304/-06 A/B outputs have already advanced by one step). The counter will only increment at the next A/B output change of the AS5304/-06.
Consequently, the module will be showing “00” for two steps in either direction (00 to +01 and 00 to -01). That is why the module only counts up to 158 (and not to 159) before the next reset occurs.

This unwanted behavior can be avoided in customer designs by using counters that accept an edge triggered reset.

On the evaluation kit, it can be avoided by setting the jumper to AC decoupled connection, which generates a short reset pulse (active low) from the rising edge of the Index output.

4 The LED outputs

The :LCD counter module also contains five LEDs (see Fig. 4).

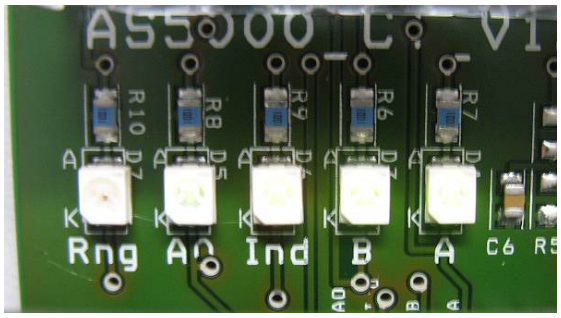


Fig. 4: LEDs on the AS5304/-06 evaluation board

The function of these LEDs are:

LED “Rng”: This LED is not used in the AS5304/-06 demo kit

LED “AO”: Analog output; this output represents the Automatic Gain Control (AGC) of the AS5304/-06). It is a variable analog voltage that is proportional to the magnetic field strength of the magnet.

AO=high, ~VDD (LED = 0ff) : weak magnetic field
AO=low, ~VSS (LED = on) : strong magnetic field
AO=0.5…4.5V (LED = variable brightness : AGC is in the recommended regulation range.

Note: the magnetic field strength is acceptable, even if the CAO-LED is off, as long as there is no magnetic field alarm (see LED “I” below)

LED “I”: Index output; will be low (LED =on) in normal operation, it will be high (LED =off) together with A=B=high (LEDs = off), when an index position is detected. An index is generated once for every polepair. (see 3.1).

This LED also indicates an “out of range” status for the magnetic field (e.g. when the magnet is too far away or removed). The magnetic field alarm is indicated by a combination of A,B and Index that does not occur in normal operation:
Index = high (LED “I” = off)
A=B = Low (LEDs “A,B” = on)
LEDs “A” and “B”: quadrature output pins of the AS5304/-06. The AS5304/-06 can interpolate one polepair into 160 steps, resulting in 40 quadrature pulses (one quadrature pulse = four discrete steps: 00, 01, 11,10)

Note: as mentioned above, a magnetic field out-of-range condition is indicated by
LEDs “A,B” = on
and LED “I” = off.

5 Using the AS5304/-06 with a multipole magnetic bar

The multipole magnetic bar is attached to the AS5304/-06 evaluation board as shown in Fig. 6 . The pins on the fixture are snapped into matching holes in the PCB.

5.1 The AS5304 strip magnet

The AS5304 will only work properly with a multipole magnet having a pole length of 2.0mm. The magnetic strip included in the AS5304 evaluation kit is a rubber bonded strontium ferrite magnet with 50 poles and a dimension of 101.6 x 5.0 x 0.76mm, mounted on a plastic bar.

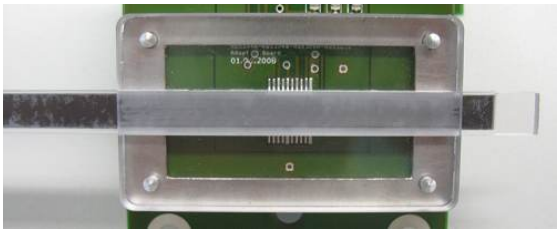


Fig. 5: attachment of the magnetic bar for AS5304

Note: the magnet strip may be ordered separately from the austriamicrosystems online web shop, article number MS20-50

5.2 The AS5306 strip magnet

The AS5306 will only work properly with a multipole magnet having a pole length of 1.2mm. The magnetic strip included in the AS5306 evaluation kit is a rubber bonded strontium ferrite magnet with 15 poles and a dimension of 19.2 x 2.5 x 0.38mm, mounted on a plastic bar.
Important note: Since the Hall sensor array is not exactly located at the horizontal chip center, the bar holding the magnet strip must be inserted such that the magnet is placed off center, towards pins#11…20 (see Fig. 6) !

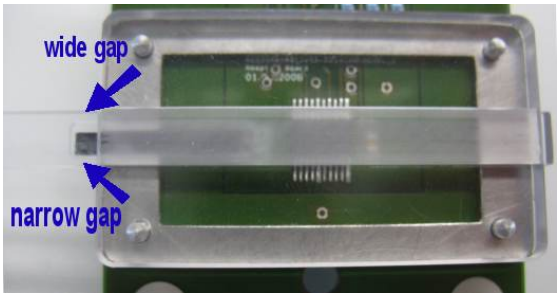


Fig. 6: attachment of the magnetic bar for AS5306

Note: the magnet strip may be ordered separately from the austriamicrosystems online web shop, article number MS12-15

5.3 Composition of the magnetic bar

The magnetic bar consists of multiple north and south poles adjacent to each other. The poles are visualized in Fig. 7 using a magnetic viewer foil. Dark spaces are showing strong magnetic fields (North or South poles), the light spaces show the neutral fields between the poles.

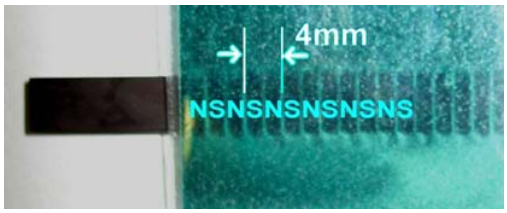


Fig. 7: pole arrangement on the 2mm pole length multipole magnetic bar

The length of one polepair (one North + one South pole) is typ. 4mm for AS5304 and 2.4mm for AS5306. The AS5304/-06 can interpolate one pole pair into 160 steps, thus the resolution for linear motion sensing is
4.0 mm/160 = 25µm per step for the AS5304 and
2.4 mm/160 = 15µm per step for the AS5306.

6 Using the AS5304/-06 with a multipole magnetic ring

Note: the multipole magnetic rings described in this chapter are not included in the present version of the AS5304/-06 evaluation kit !

The AS5304/-06 may be used with either multipole strips or rings. When using a multipole ring (not included in the evaluation kit), the pole pairs of the ring must match the same requirements as for a multipole magnetic bar, essentially that the magnetic polepair length is 4mm (2mm north pole + 2mm nouth pole) for the AS5304 and 2.4mm for the AS5306.

Hence the number of polepairs determines the circumference of the magnet and the attainable resolution.

6.1 Calculating the resolution of a multipole magnetic ring

Each polepair is interpolated into 160 steps (= 40 quadrature pulses) by the AS5304/-06. Consequently, the larger the diameter of the magnet, the more polepairs fit on the ring and the higher will be the resolution:

Number of polepairs: $p\_p = (d*\pi) / 4mm$

Resolution (steps) $= p\_p * 160$
$= 40 *d *\pi$

Resolution (bit) $= \log(p\_p *160) / \log (2)$
$= \log (40 *d *\pi) / \log (2)$

where: d= diameter of magnetic ring in mm
p_p = number of polepairs

6.2 Calculating the maximum rotational speed

The AS5304/-06 can accept an input frequency of up to 5kHz, respectively a speed of 5000 polepairs per second.
For linear motion sensing, assuming 4mm polepair length, this means 5000 polepairs per sec * 4mm = 20m/sec.

For rotary motion sensing, this maximum speed of 20m/sec equals the circumferential speed of the magnetic ring.
The rotational speed can be calculated by:

max.speed (rev.per sec) = $20.000 / (d *\pi)$

max.speed (rpm) = $1200000 / (d *\pi)$

where: d= ring diameter in mm

or, if the number of polepairs are known:

max.speed (rpm) = 60 * 5kHz / polepairs
= 300 000 / polepairs

Example: magnetic ring, 22 polepairs

diameter = $22 * 4mm / \pi$ = 28,011 mm

resolution = polepairs * 160 = 3520 steps
$= 40 *d *\pi$ = 3520 steps
$= \log(3520)/\log(2)$ = 11,78 bits

max. speed = $1.2E6 /(d*\pi)$ = 13 636 rpm
= 3E5 / 22 = 13 636 rpm

7 Sensor Placement in Package

Note that the Hall sensor array is not located exactly at the chip center. The scanning area is located 1.02mm off the horizontal chip center towards the row of pins #11...20. It is therefore essential to place the magnetic strip or ring such that it is centered over the Hall sensor array.

TSSOP20 / 0.65mm pin pitch

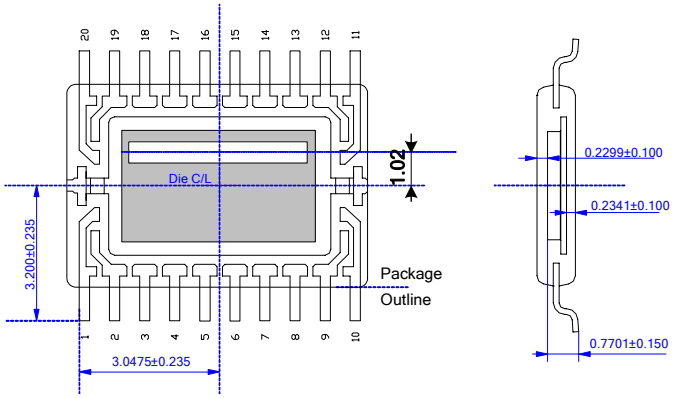


Fig. 8: Sensor in Package

8 AS5304/-06 adapterboard schematic

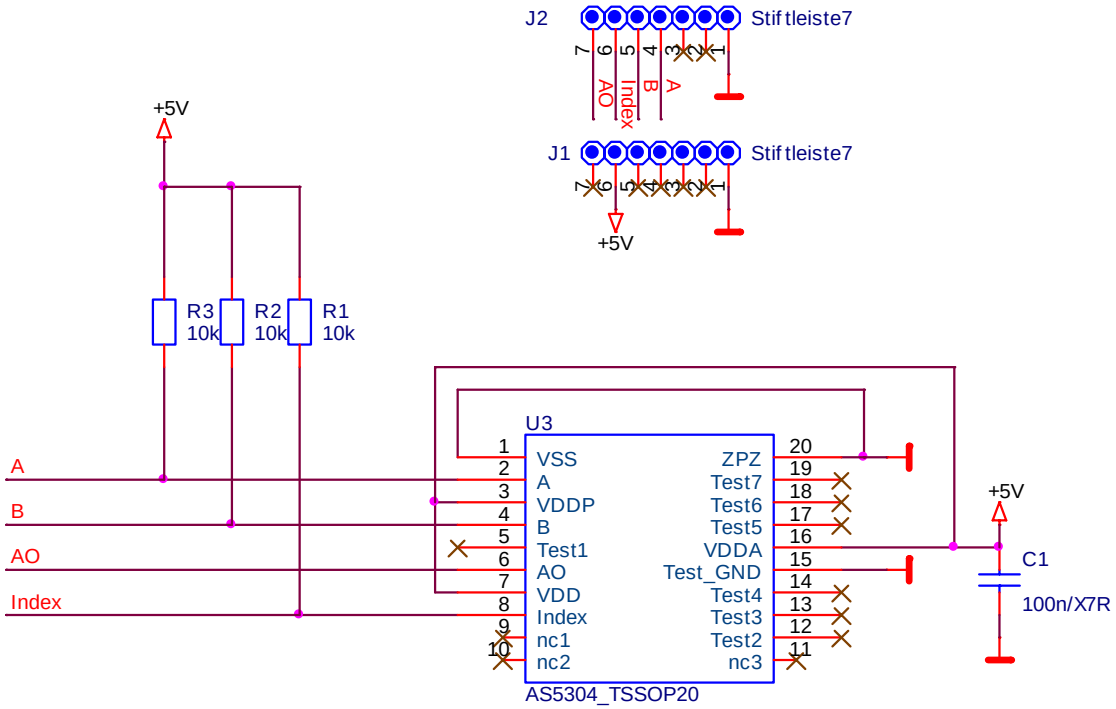


Fig. 9: AS5304/-06 adapterboard schematic

Since the AS5304 and AS5305 are pin-compatible, the AS5304/-06 adapterboard accepts both chips. Another chip option is the choice of push-pull outputs (-A versions) and open-drain outputs (-B versions).
If push-pull outputs are installed, resistors R1...R3 must not be installed. These resistors should only be installed for the open-drain versions.

9 Counter Module Schematic

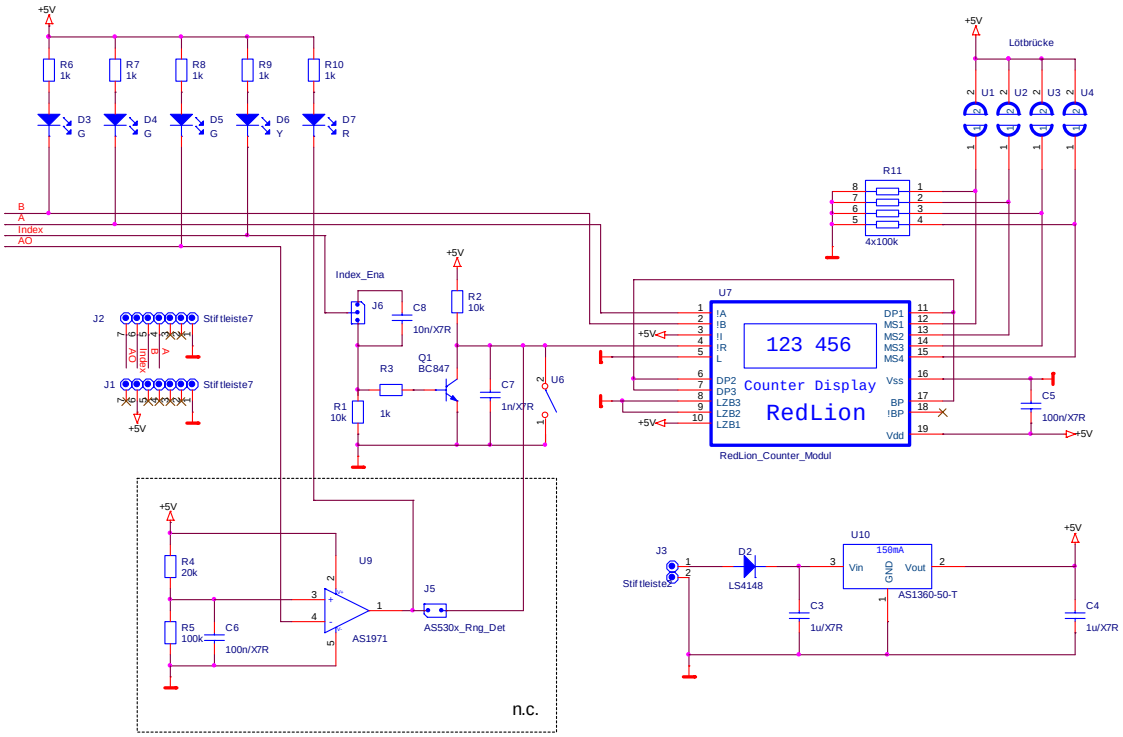


Fig. 10: Counter module schematic

The counter module essentially only requires the signals A, B and Index from the AS5304/-06 adapterboard. Since the Index output in the AS5304/-06 is active high and the counter module requires an active low reset, the index output is inverted by transistor Q1. Jumper J6 is set to “AC decoupled Index” per default and enables a reset of the counter by an index pulse. Pushbutton U6 (in parallel to Q1, C-E) allows a manual reset of the counter. U1…U4 are solder bridges used to configure the module. They should not be changed from the default setting: U1,U4 = shorted, U2, U3 = open.

The AS5304/-06 outputs A, B, Index and AO are connected to LEDs with series resistors at +5V. A 5V LDO generates the necessary power supply for both the AS5304/-06 and the counter module from a 9V battery. The voltage supervisor circuit (U9) along with 3 passive components (R4, R5, C6) is not installed in this version of the counter module.

10 Contact

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