iC-MHA

ANALOG ANGULAR HALL SENSOR

preliminary

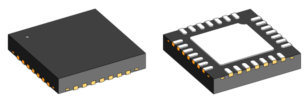
FEATURES

- Differential sine and cosine output signals
- Magnetic rotation speed up to 20,000 rpm
- Low output offset supporting 10bit interpolation accuracy
- Reasonable alignment tolerance
- Automatic gain control for 0.8 to 1.2 Vpp output signal
- Loss of magnet detection and error message indication
- Extended temperature range of -40 to +125 °C

APPLICATIONS

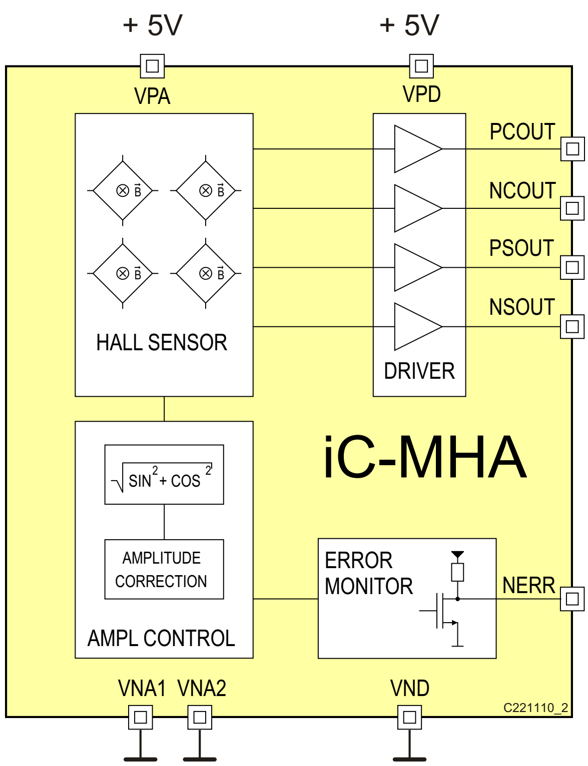
- Absolute angular encoder
- Brushless motors
- Motor feedback
- Rotational speed control

PACKAGES



QFN28 5 x 5 mm^2

BLOCK DIAGRAM



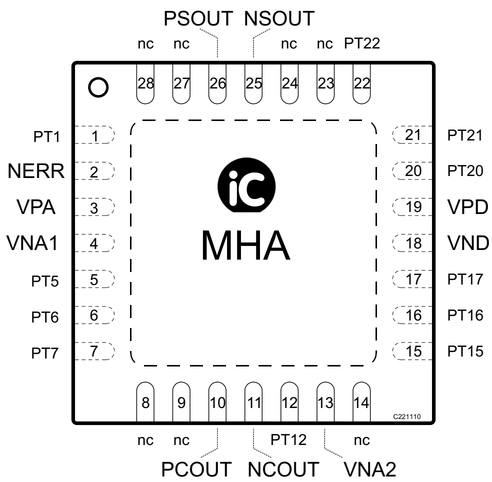
DESCRIPTION

The iC-MHA is a position sensor with integrated Hall sensors for scanning a permanent magnet. The signal conditioning unit generates constant-amplitude sine and cosine voltages that can be used for angle calculation.

Sine and cosine signals are availabe via line driver outputs (100 Ω load)

PACKAGING INFORMATION QFN28 5 x5 mm² to JEDEC MO-220-VHHD-1

PIN CONFIGURATION QFN28 5 x 5mm²



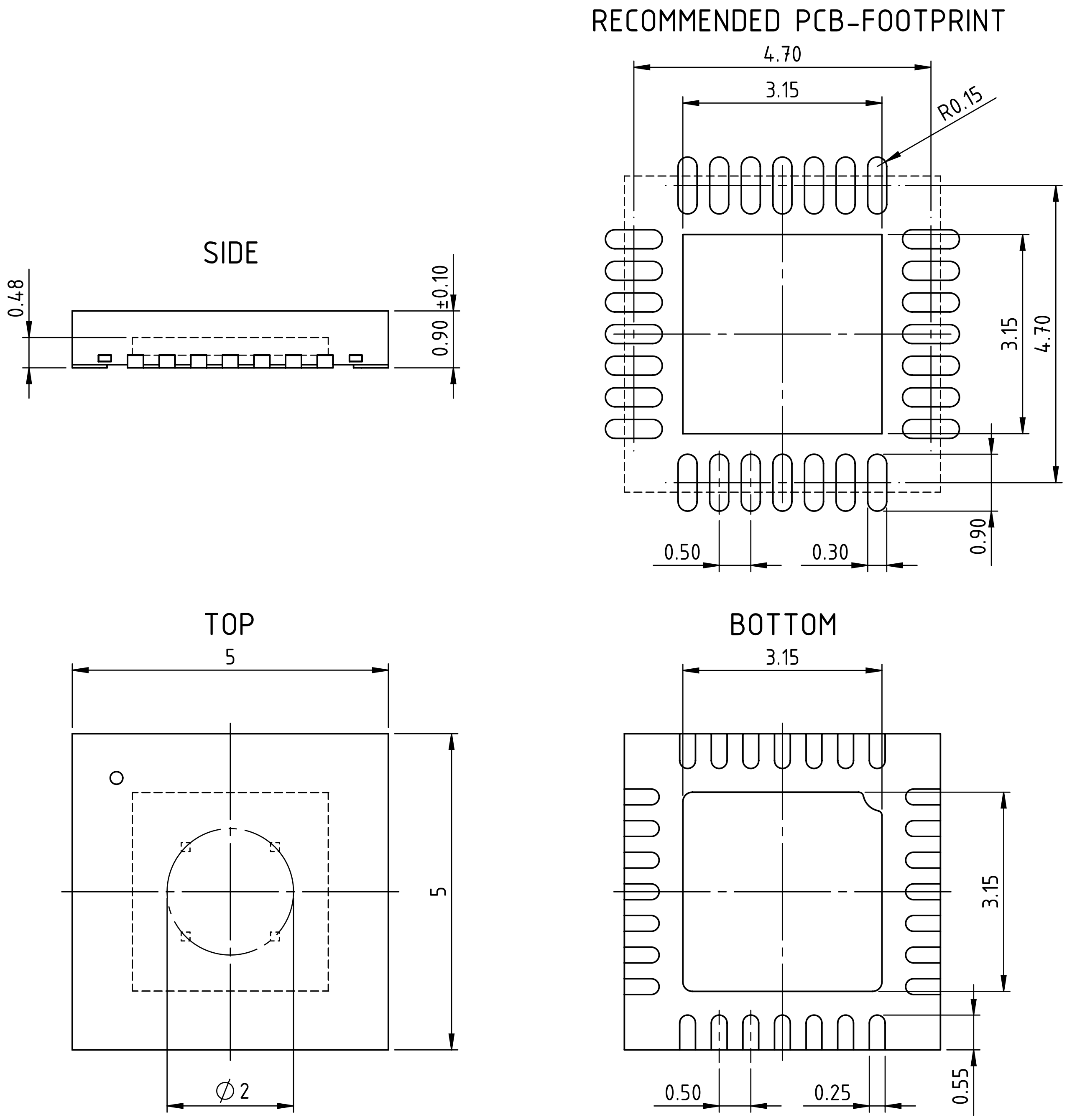
PIN FUNCTIONS

No.	Name	Function
2	NERR	Error Output (active low)
3	VPA	+5 V Analog Supply Voltage
4,13	VNA1, VNA2	Analog Ground
10	PCOUT	Positive Cosine Output
11	NCOUT	Negative Cosine Output
18	VND	Digital Ground
19	VPD	+5 V Digital Supply Voltage
25	NSOUT	Negative Sine Output
26	PSOUT	Positive Sine Output
	TP	Thermal-Pad
8,9	nc	not connected
14	nc	not connected
23,24	nc	not connected
27,28	nc	not connected
		Pins for device test and factory calibration:
1	PT1	connect to VND
5	PT5	connect to VND
6	PT6	connect to VPD
7	PT7	do not connect (leave open)
12	PT12	connect to VND
15	PT15	do not connect (leave open)
16	PT16	do not connect (leave open)
17	PT17	do not connect (leave open)
20	PT20	do not connect (leave open)
21	PT21	do not connect (leave open)
22	PT22	do not connect (leave open)

The *Thermal Pad* is to be connected to VNA1, VNA2 and heat sink area.
Orientation of package marking is subject to alteration (iC MHA code etc.).

PACKAGE DIMENSIONS

All dimensions given in mm.



All dimensions given in mm.
Tolerances of form and position according to JEDEC MO-220.
Tolerance of sensor pattern: ±0.10mm / ±1° (with respect to center of backside pad).

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ABSOLUTE MAXIMUM RATINGS

These ratings do not imply operating conditions; functional operation is not guaranteed. Beyond these ratings device damage may occur.

Item No.	Symbol	Parameter	Conditions	Min.	Max.	Unit
G001	V()	Voltages at VPA, VPD		-0.3	6	V
G002	V(PT12)	Voltage at PT12		-0.3	8	V
G003	V()	Voltages at NERR, PSOUT, NSOUT, PCOUT, NCOUT, PT1, PT5, PT6, PT7, PT15, PT16, PT17, PT20, PT21, PT22		-0.3	6	V
G004	I()	Current in VPA		-10	20	mA
G005	I()	Current in VPD		-20	200	mA
G006	I()	Current in NERR, PT1, PT5, PT6, PT7, PT15, PT16, PT17, PT20, PT21, PT22		-10	10	mA
G007	I()	Current in PSOUT, NSOUT, PCOUT, NCOUT		-50	50	mA
G008	Vd()	ESD Susceptibility at all pins	HBM 100 pF discharged through 1.5 kΩ		2	kV
G009	Tj	Junction Temperature		-40	150	°C
G010	Ts	Storage Temperature		-40	150	°C

THERMAL DATA

Operating conditions: VPA = VPD = 5 V ±10 %

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T01	Ta	Operating Ambient Temperature Range		-40		125	°C
T02	Rthja	Thermal Resistance Chip to Ambient	surface mounted to PCB, thermal pad linked to cooling area of approx. 2 cm²		40		K/W

All voltages are referenced to ground unless otherwise stated.
All currents flowing into the device pins are positive; all currents flowing out of the device pins are negative.

ELECTRICAL CHARACTERISTICS

Operating conditions:
VPA = VPD = 5 V ±10 %, VNA = VND, Tj = -40...125 °C, 4 mm NdFeB magnet, unless otherwise noted

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
General							
001	V(VPA), V(VPD)	Permissible Supply Voltage		4.5		5.5	V
002	I(VPA)	Supply Current in VPA		3		12	mA
003	I(VPD)	Supply Current in VPD	without load	2		18	mA
004	Vc()hi	Clamp Voltage hi at NERR	Vc()hi = V() − VPD, I() = 1 mA	0.4		1.5	V
005	Vc()lo	Clamp Voltage lo at NERR	I() = -1 mA	-1.5		-0.3	V
Hall Sensors							
101	Hext	Operating Magnetic Field Strength	at surface of chip	20		100	kA/m
102	fmag	Operating Magnetic Field Frequency Rotating Speed of Magnet				330 20 000	Hz rpm
103	dsens	Diameter Of Hall Sensor Array			2		mm
104	xdis	Max. Magnet Axis Displacement vs. Center Of Hall Sensor Array				0.2	mm
Signal Level Control							
201	Vpp	Differential Peak-To-Peak Output Amplitude	Vpp = Vpk(Px) − Vpk(Nx), see Fig. 5	0.8		1.2	Vpp
202	ΔVpk()	Amplitude Ratio Error	Vpk(PSIN-NSIN) vs. Vpk(PCOS-NCOS)		1		%
203	ΔVos()	Offset Error			0.2		%
204	ton	Controller Settling Time	to ±10% of final amplitude			300	µs
205	Vt()lo	MINERR Amplitude Error Threshold	see 201	0.3		0.7	Vpp
206	Vt()hi	MAXERR Amplitude Error Threshold	see 201	1.25		1.45	Vpp
Error Message Output NERR							
905	Ipu()	Pull-up Current Source	V(NERR) = 0...VPD − 1 V	-800	-300	-80	µA
906	Isc()lo	Short-Circuit Current Lo	V(NERR) = V(VPD), Tj = 25 °C		50	80	mA
907	tf()hilo	Decay Time	CL = 50 pF			60	ns
Analog Output Line Driver PSOUT, NSOUT, PCOUT, NCOUT							
Q01	Vpk()	Permissible Max. Output Signal Amplitude	RL = 50 Ω vs. VDD / 2, see Fig. 1			300	mV
Q02	Vos()	Output Offset Voltage			±1		mV
Q03	fc()	Output Cut-off Frequency	CL = 250 pF	10			kHz
Q04	Isc()hi, lo	Output Short-circuit Current	pin shorten to VPD or VND	10		50	mA

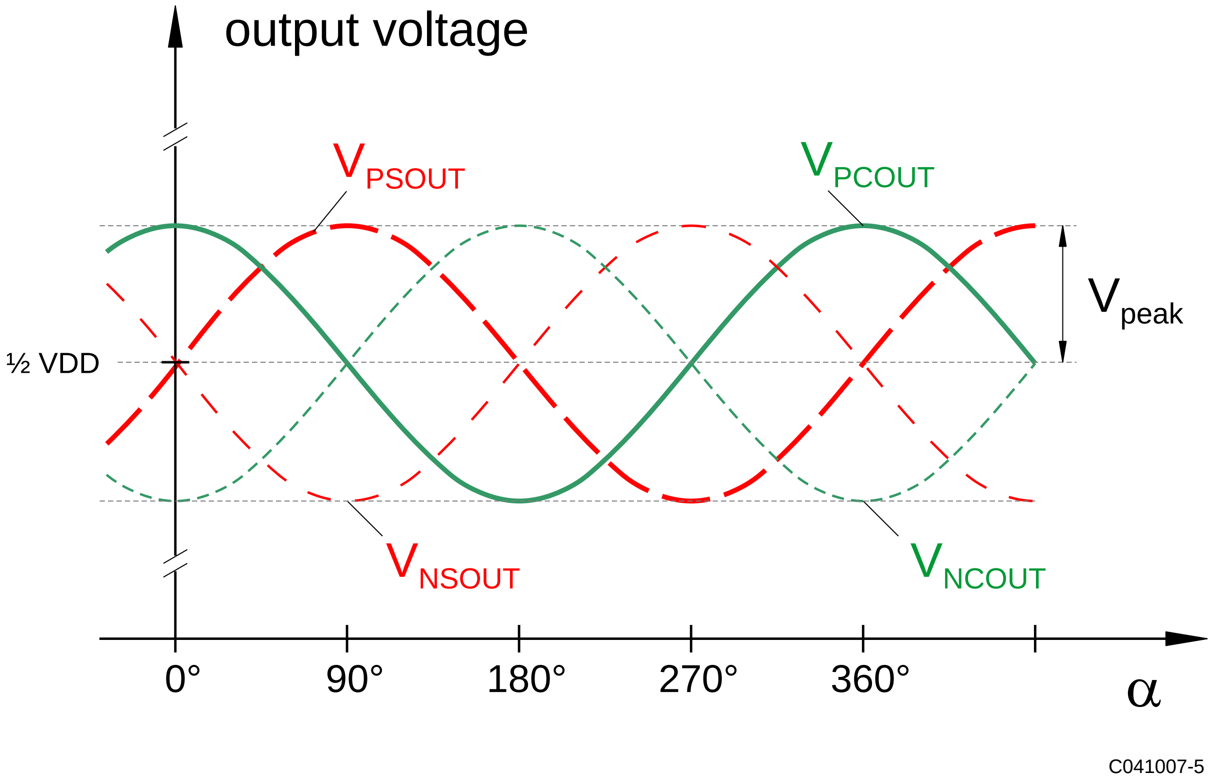

Figure 1: Definition of output signal amplitude

SENSOR PRINCIPLE

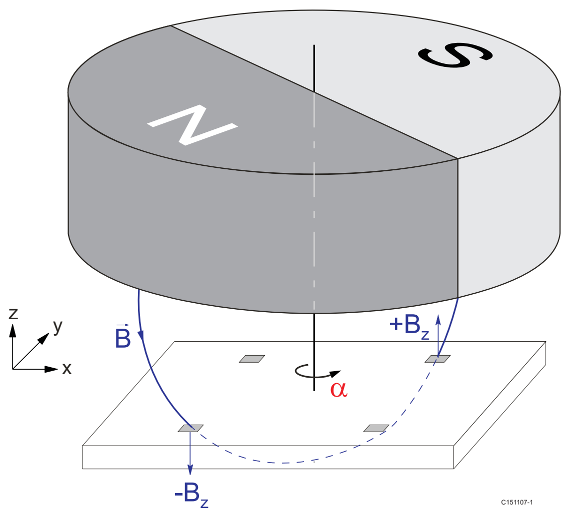

Figure 2: Sensor principle

In conjunction with a rotating permanent magnet, the iC-MHA module can be used to create a complete encoder system. A diametrically magnetized, cylindrical permanent magnet made of neodymium iron boron (NdFeB) or samarium cobalt (SmCo) generates optimum sensor signals. The diameter of the magnet should be in the range of 3 to 6 mm.

The iC-MHA has four Hall sensors adapted for angle determination and to convert the magnetic field into a measurable Hall voltage. Only the z-component of the magnetic field is evaluated, whereby the field lines pass through two opposing Hall sensors in the opposite direction. Figure 2 shows an example of field vectors. The arrangement of the Hall sensors is selected so that the mounting of the magnets relative to iC-MHA is extremely tolerant. Two Hall sensors combined provide a differential Hall signal. When the magnet is rotated around the longitudinal axis, sine and cosine output voltages are produced which can be used to determine angles.

Position of the Hall sensors and the analog sensor signal

The Hall sensors are placed in the center of the QFN28 package at 90° to one another and arranged in a circle with a diameter of 2 mm as shown in Figure 3.

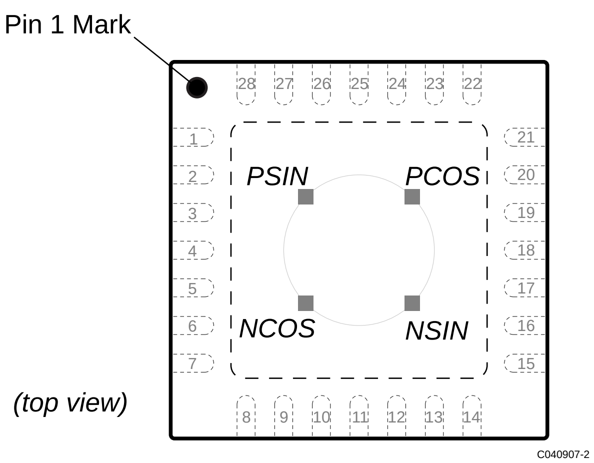

Figure 3: Position of the Hall sensors

When a magnetic south pole comes close to the surface of the package the resulting magnetic field has a positive component in the +z direction (i.e. from the top of the package) and the individual Hall sensors each generate their own positive signal voltage.

In order to calculate the angle position of a diametrically polarized magnet placed above the device a difference in signal is formed between opposite pairs of Hall sensors, resulting in the sine being $V_{SIN} = V_{PSIN} - V_{NSIN}$ and the cosine $V_{COS} = V_{PCOS} - V_{NCOS}$. The zero angle position of the magnet is marked by the resulting cosine voltage value being at a maximum and the sine voltage value at zero.

This is the case when the south pole of the magnet is exactly above the PCOS sensor and the north pole is above sensor NCOS, as shown in Figure 4. Sensors PSIN and NSIN are placed along the pole boundary so that neither generate a Hall signal.

When the magnet is rotated counterclockwise the poles then also cover the PSIN and NSIN sensors, resulting in the sine and cosine signals shown in Figure 5 being produced.

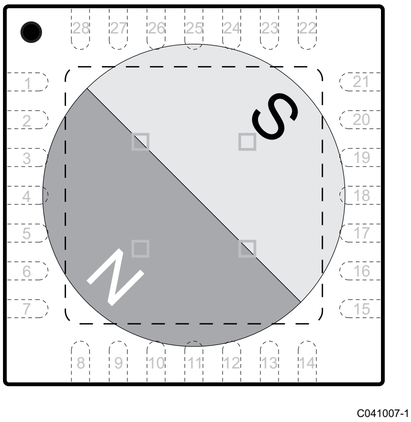

Figure 4: Zero position of the magnet

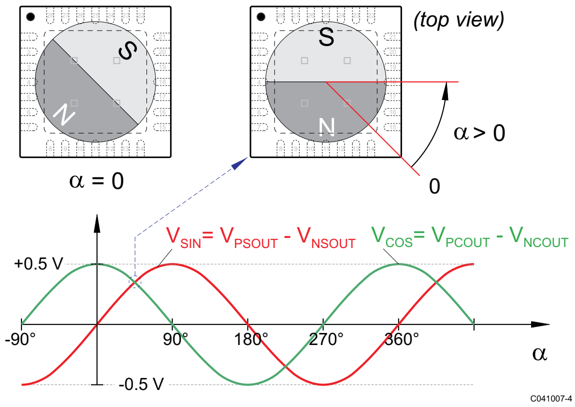

Figure 5: Pattern of the analog sensor signals with the angle of rotation

REVISION HISTORY

Rel	Rel.Date	Chapter	Modification	Page
A1	13-05-08		first release for web upload	

Rel	Rel.Date	Chapter	Modification	Page
B1	14-05-13	PACKAGING INFORMATION	recommended connection of pins 15, 16, 17, 20, 21, 22 changed to "do not connect"	2
		PACKAGING INFORMATION	package dimension drawing now includes hall sensor location and position tolerance	3
		ABSOLUTE MAXIMUM RATINGS	G002, G003 and G006: descrption extended for all PT-Pins G007: added for analog output pins PSOUT, NSOUT, PCOUT, NCOUT G009, G010: max. values increased to 150°C	4
		ELECTRICAL CHARACTERISTICS	former items 105 to 107 omitted, as mechanical tolerances are given in package dimensions on page 3	5
		SENSOR PRINCIPLE	color style of Figure 2 changed	7
		Position of the Hall sensors and the analog sensor signal	color style of Figure 4 and 5 changed	8

Rel	Rel.Date	Chapter	Modification	Page
B2	14-05-15		revision history added (this chapter)	9

ORDERING INFORMATION

Type	Package	Order Designation
iC-MHA	QFN28	iC-MHA QFN28-5x5

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