Features and Benefits

- Based on advanced magnetic field sensing technology
- Measures magnetic field direction rather than field intensity
- Non-contacting angle measurement
- Large air gap
- Excellent accuracy, even for weak magnetic field
- Position tolerant
- Single chip solution
- User programmable resolution & zero / index position
- RoHS Compliant 2011/65/EU

Applications

- Replacement of optical encoders
- Robotics control
- BLDC motor commutation
- Power tools

General Description

The MagnTek rotary position sensor MT6801 is an IC based on advanced magnetic field sensing technology. The sensor contains two Wheatstone bridges formed by a magnet field sensing element array. A rotating magnetic field in the x-y sensor plane delivers two sinusoidal output signals indicating the angle (α) between the sensor and the magnetic field direction. Within a homogeneous field in the x-y plane, the output signals are relatively independent of the physical placement in the z direction (air gap).

The sensor is only sensitive to the magnetic field direction as the sensing element output is specially designed to be independent from the magnet field strength. This allows the device to be less sensitive to magnet variations, stray magnetic fields, air gap changes and off-axis misalignment.

Three incremental output modes are available in this sensor series, making the chip suitable to replace various optical encoders.

Pin Configuration

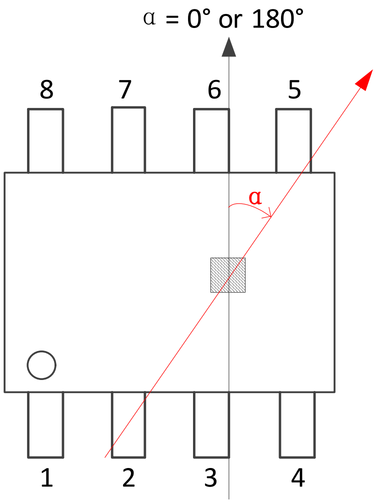


Figure 1: Pin Configuration for SOP-8 Package, Showing Zero Degree Position

Name	Number	Type	Description
MODE	1	Digital input	Connect to logic low for normal operation; Connect to logic high for I^2C mode.
NSP	2	Digital input or Analog output	Optional magnetic switch input or linear output
GND	3	Ground	Ground
VDD	4	Supply	5V supply
Z/W/Index	5	Digital output	Z or W or Index output
HVPP	6	Supply	7.5 supply only needed for NVM programming. NC for normal operation.
B/V/Dir/SCL	7	Digital I/O	B or V or Dir output or I^2C clock
A/U/Step/SDA	8	Digital I/O	A or U or Step output or I^2C data

Family Members

Part number	Description
MT6801CT-XYZ	SOP-8 package, tape and reel packaging (3000pcs/bag)

X: Output type, A=ABZ, U=UVW, S=SDI

Y (ABZ or SDI mode): Resolution, 8=8-bit, 9=9-bit, A=10-bit, B=11-bit, C=12-bit

Y (UVW mode): Number of pulses per rotation, 2=2-pulse, 4=4-pulse, 6=6-pulse, H=16-pulse

Z: Options, D=default, V=output inverted, H=MS input enabled, L=linear output enabled

SOP-8 Reflow Sensitivity Classification: MSL 3

Functional Description

The MT6801 is manufactured in a CMOS standard process and uses advanced magnet sensing technology to sense the magnetic field distribution across the surface of the chip. The integrated magnetic sensing element array is placed around the center of the device and delivers a voltage representation of the magnetic field at the surface of the IC.

Figure 2 shows a simplified block diagram of the chip, consisting of the magnetic sensing element realized by two interleaved Wheatstone bridges to generate cosine and sine signals, gain stages, analog-to-digital converters (ADC) for signal conditioning, and a digital signal processing (DSP) unit for encoding. Other supporting blocks such as LDO, etc. are also included.

A small low cost diametrically magnetized (two-pole) standard magnet can be used to provide angular position information. The MT6801 senses the rotation and orientation of the magnetic field and generates incremental outputs. The following 3 incremental output modes are available.

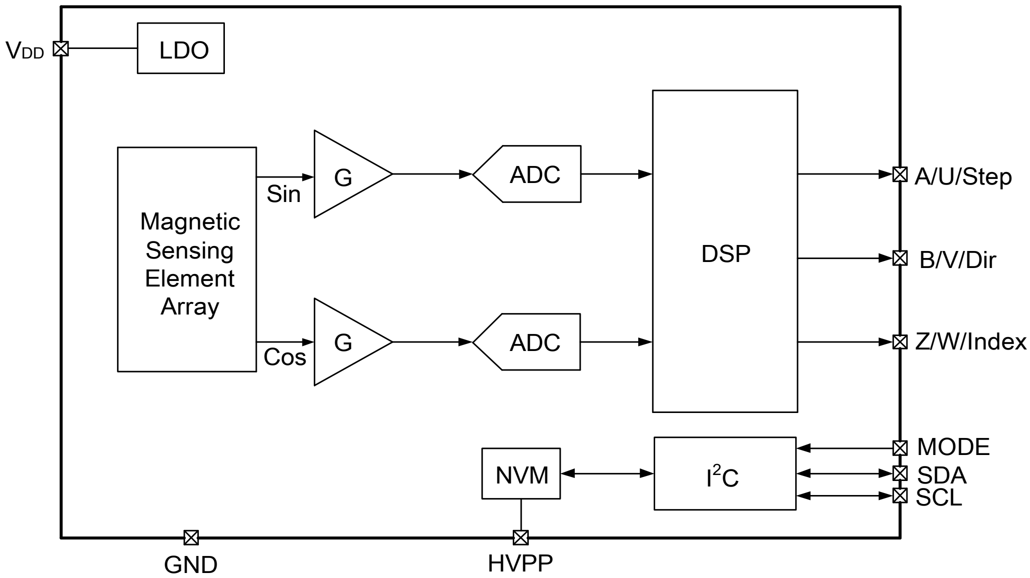


Figure 2: Simplified System Block Diagram

Quadrature A/B and Zero-position output signal

As depicted in
Figure 3, when the magnet rotates clock-wise (CW), output A leads output B by 1/4 cycle (or 1 LSB); When the magnet rotates counter-clock-wise (CCW), output B leads output A by 1/4 cycle. Output Z indicates the zero position of the magnet and has a pulse width of 1 LSB. Its position can be programmed to align with the mechanical zero position. The hysteresis size is set to 0.5 LSB.

Step / Direction and Index output signal

In this mode, output Step has a pulse width of 1 LSB; Output Dir indicates the direction of the magnet rotation; Output Index is the same as output Z in Quadrature A/B mode.

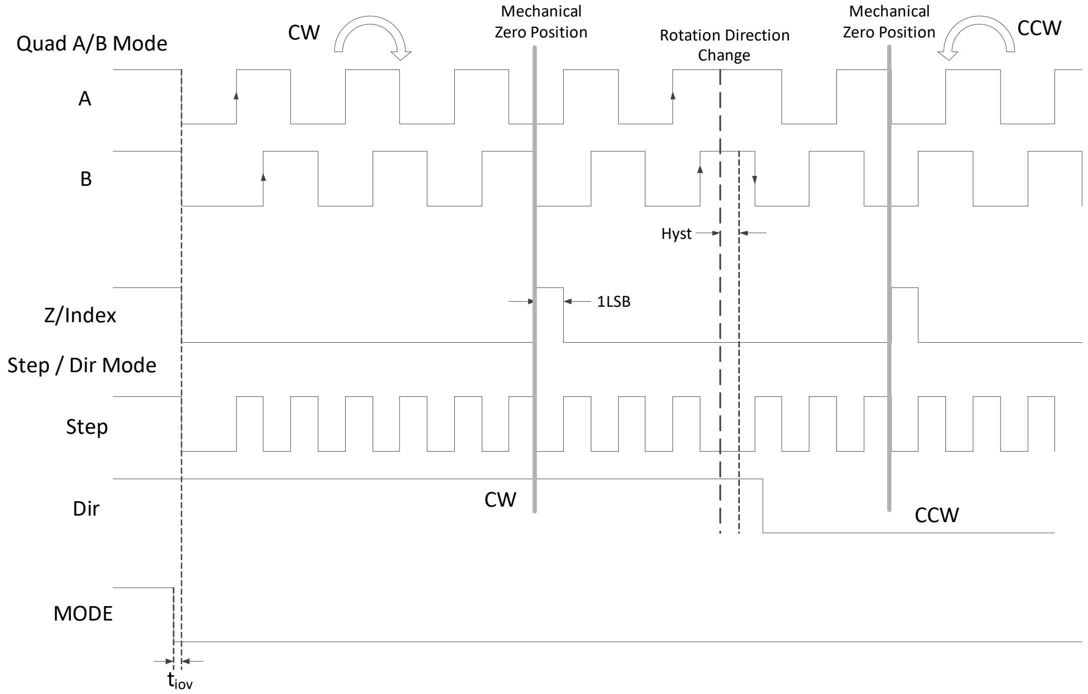


Figure 3: Typical Output Waveform for A/B/Z and Step/Dir/Index mode

3-phase Commutation for Brushless DC Motors (U/V/W)

As depicted in Figure 4, output U, V and W are 120 degrees (electrical) out of phase. The number of pulses per rotation can be programmed to 2, 4, 6 or 16. Pin-out definition varies with the number-of-pulse selection as follows.

Number-of-pulse	U	V	W
2, 6, 16	Pin 8	Pin 7	Pin 5
4	Pin 5	Pin 7	Pin 8

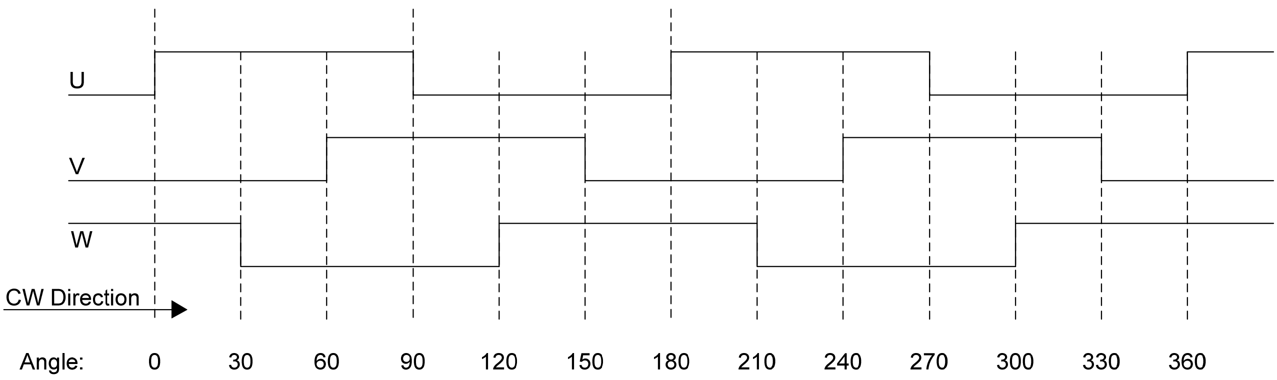


Figure 4: Typical Output Waveform for U/V/W mode

Absolute Maximum Ratings (Non-Operating)

Stresses beyond those listed under “Absolute Maximum Ratings “may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under “Operating Conditions” is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Notes	Min	Max	Unit
DC voltage at pin VDD	-	-0.3	8	V
DC voltage at pin HVPP	-	-0.3	8	V
Storage temperature	-	-55	160	°C
Operating Temperature	-	-40	150	°C
Electrostatic discharge (HBM)	Norm: AEC-Q100-2	-	± 4	kV

Electrical Characteristics

Operating conditions: Ta= -40 to +150°C, VDD= 3.0-5.5V unless otherwise noted.

Symbol	Parameter	Conditions/Notes	Min	Typ	Max	Unit
VDD	Supply Voltage	-	3.0	5	5.5	V
HVPP	Supply Voltage	-	7.25	7.5	7.75	V
Idd	Supply Current	-	-	3.0	4.0	mA
LSB	Resolution (ABZ or SDI mode)	8-bit	-	1.406	-	Degrees
LSB		9-bit	-	0.703	-	Degrees
LSB		10-bit	-	0.352	-	Degrees
LSB		11-bit	-	0.176	-	Degrees
LSB		12-bit	-	0.088	-	Degrees
INL	Integral Non-Linearity	Note (1)	-	±1	±1.5	Degrees
DNL	Differential Non-Linearity (ABZ mode)	8, 9, 10-bit	-	-	±0.1	LSB
		11, 12-bit	-	-	±0.5	LSB
TN	Transition Noise	ABZ 8, 9, 10-bit or UVW mode	-	-	0.011	Deg-rms
		ABZ 11, 12-bit	-	-	0.004	Deg-rms
Hyst	Hysteresis (ABZ mode)	8, 9-bit	-	0.5	-	LSB
		10, 11, 12-bit	-	0.75	-	LSB
T_{PwrUp}	Power-up Time	-	-	-	1.1	ms
T_{delay}	Propagation Delay	ABZ 8, 9, 10-bit or UVW mode	-	160	200	µs
		ABZ 11, 12-bit	-	1100	1140	µs
Digital I/O Characteristics (Push-Pull Type in Normal Mode)						
V_{IH}	High level input voltage	-	VDD-1	-	-	V
V_{IL}	Low level input voltage	-	-	-	0.8	V
V_{OH}	High level output voltage	I_{OH}=4.1mA	VDD-1	-		V

V_{OL}	Low level output voltage	I_{OL}=3.3mA	-	-	0.4	V
I_{LK}	Input Leakage Current	-	-	-	±1	μA
Timing Specifications						
t_{iov}	Incremental Output Valid Time	-	-	-	1	μs

Notes: (1) The typical error value can be achieved at room temperature and with no off-axis misalignment error. The max error value can be achieved over operation temperature range, at maximum air gap and with worst-case off-axis misalignment error.

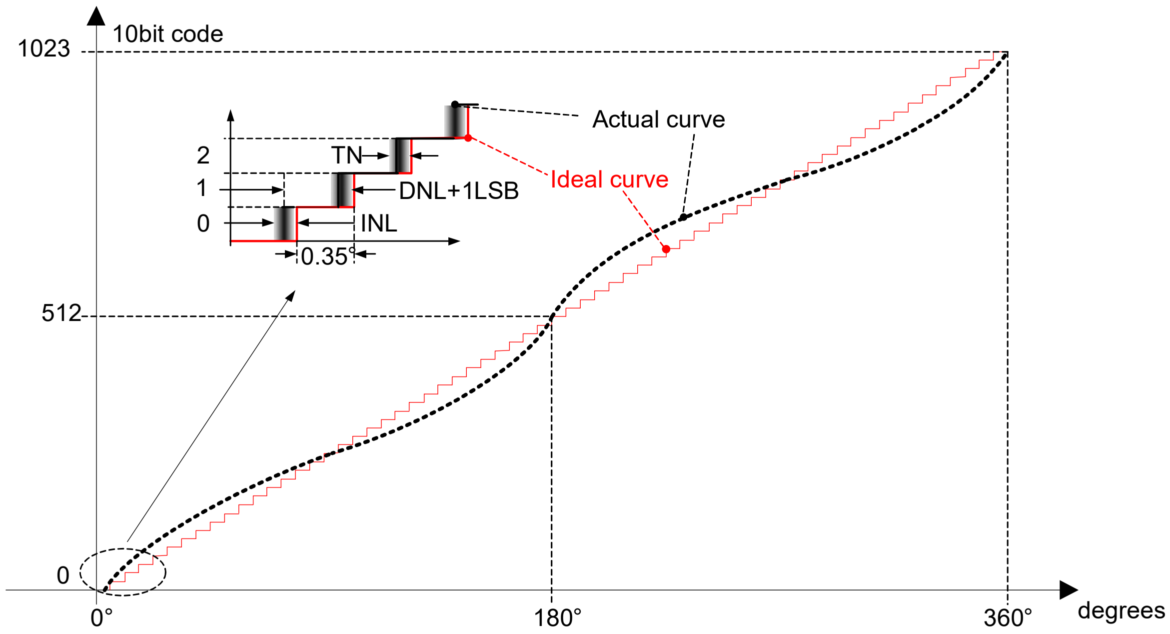


Figure 5: Drawing illustrating INL, DNL and TN (for 10-bit case)

Magnetic Input Specification

Operating conditions: Ta= -40 to +150°C, VDD= 3.0-5.5V unless otherwise noted. Two-pole cylindrical diametrically magnetized source.

Symbol	Parameter	Notes	Min	Typ	Max	Unit
Dmag	Diameter	Recommended magnet: Ø8mm x 2.5mm for cylindrical magnets	-	8	-	mm
Tmag	Thickness	-	-	2.5	-	mm
Bpk	Magnetic input field amplitude	Measured at the IC surface.	300	-	3000	Gauss
AG	Air Gap	Magnet to IC surface distance (Figure 6).	1.0	-	3.0	mm
RS	Rotation Speed	8, 9, 10-bit resolution or UVW mode	-	-	15	KRPM
		11, 12-bit resolution	-	-	7	KRPM
DISP	Displacement	Misalignment error between	-	-	0.3	mm

	Radius	sensor center and magnet axis (Figure 6).				
TCmag1	Recommended magnet material and temperature drift	NdFeB (Neodymium Iron Boron)	-	-0.12	-	%/°C
TCmag2		SmCo (Samarium Cobalt)	-	-0.035	-	

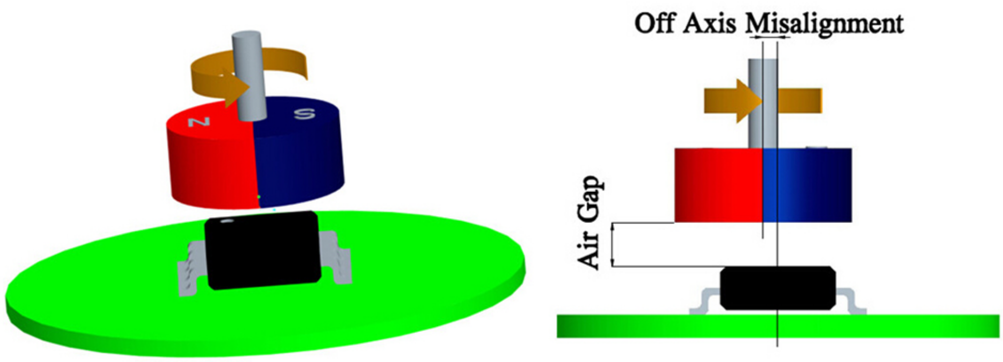


Figure 6: Magnet Arrangement

Application Information

Reference Circuit

Figure 7 shows a reference circuit for typical applications. A ferrite bead (FB1) and a TVS diode (D1) are added for supply transient protection and filtering. For applications where heavy resistive or capacitive load need to be driven, it is recommended that external driver composed of transistors be added at the outputs. The reference circuit shown also applies to applications that use SDI or UVW output, where pin assignment may differ (please refer to the previous section for details).

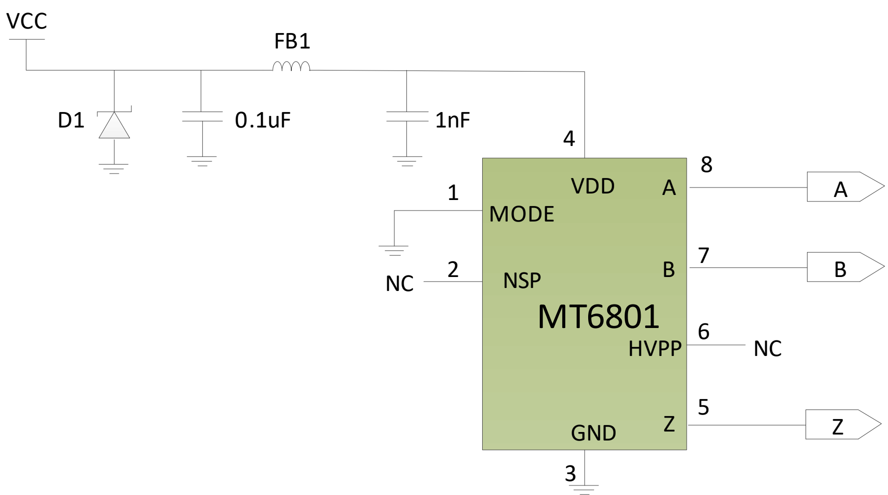


Figure 7: Reference Application Circuit

Magnet Selection and Placement

It is recommended that the magnetic field density at the chip surface reaches 300 Gauss to guarantee that the magnetic sensing elements operate in saturation mode to ensure good linearity. Please be noted that the sensing element in the chip is not at the package center, rather it is aligned with PIN 3 and 6 edges (see the figures in the “Package Information” section). It is required that the magnet’s center axis be aligned with the sensing element center. Any misalignment introduces additional angle error. Magnets with larger radius are more tolerant to off-axis misalignment. It also allows the magnet to be placed at the large air gap distance from the chip.

Programming

MT6801 can be programmed through dedicated programmer PB02 with its companion GUI software.
The following parameters can be programmed: resolution, output mode, zero position, external MS input and optional linear output.

Notes on Zero/Index Signal

The magnetic sensing element used in the IC has a period of 180 degrees, which means two Zero/Index pulses are generated for every magnet rotation, at 0 and 180 degree respectively. For applications that require only one Zero/Index pulse, an external magnetic switch sensor can be added to meet the requirement. Please contact Magntek’s technical support team for further assistance.

Optional Linear Output

For applications that need to obtain the absolute angle position of the magnet at power-up, an optional linear output is available to achieve this goal. MT6801 can be programmed to put out an analog voltage that is proportional to the angle position on NSP pin. For more details about how to use the linear output, please contact Magntek’s technical support team.

Delay-Induced Angle Error

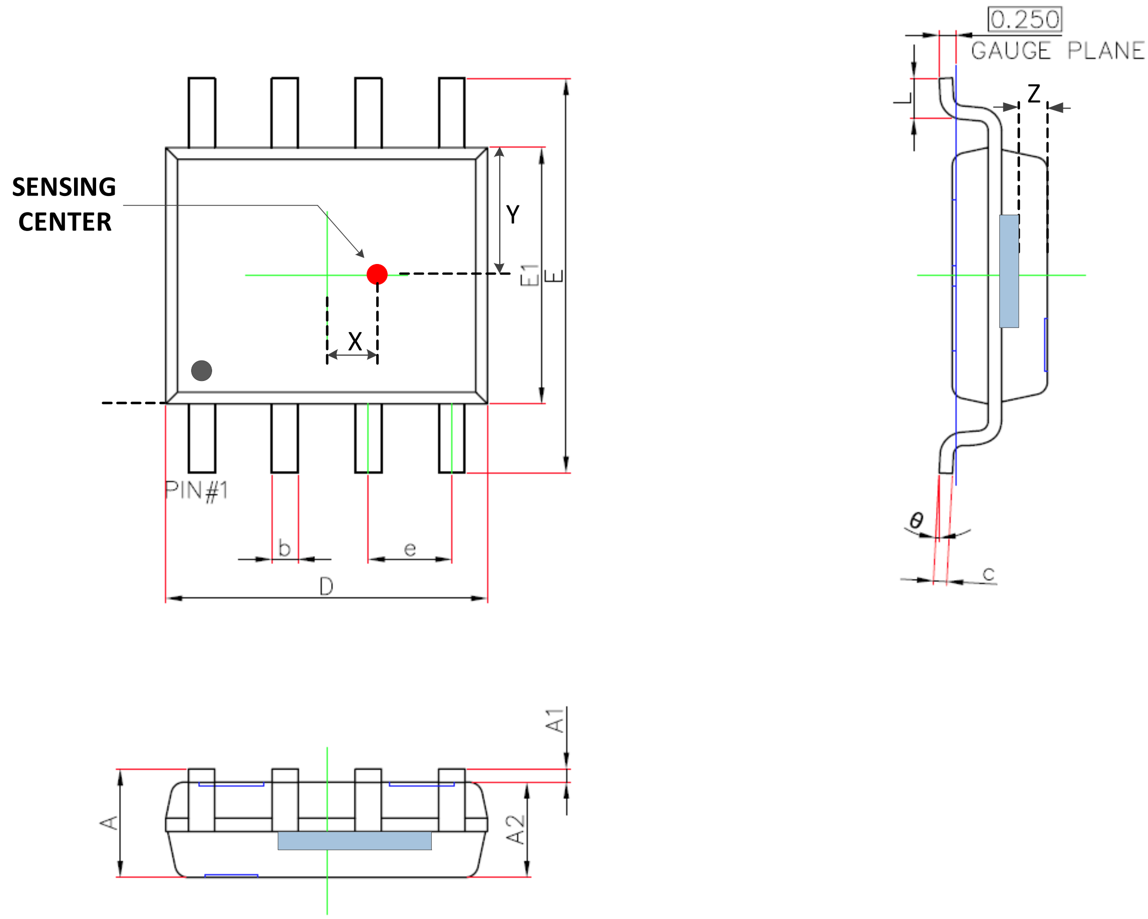
Sampling and signal processing introduce propagation delay in the chip, which can cause angle error for a continuously rotating magnet. The amount of angle error induced is proportional to the rotation speed Spd (in rpm) and delay time T_{delay} (in seconds). For example, a delay time of 100 us at a rotation speed of 1000 rpm leads to 0.6 degrees of error. The general formula is as follows.

$$e = 6 \cdot \mathrm{Spd} \cdot T_{delay}$$

If the speed is steady and the delay is known, this error is predictable, hence can be compensated in the controller stage in the system.

PACKAGE DESIGNATOR

(MT6801CT) SOP-8



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	0.800	0.016	0.031
θ	0°	8°	0°	8°
X	0.86		0.034	
Y	1.830	2.030	0.072	0.080
Z	0.526	0.609	0.021	0.024