

AM256L – Angular magnetic encoder IC

Features

- Contactless angular position encoding over 360°
- Ideal for harsh environments due to magnetic sensing
- Complete system-on-chip solution
- 8 bit absolute encoder
- Output options:
 - Incremental
 - Parallel
 - Serial SSI
 - Analogue sinusoidal
- Factory optimized linearity
- High rotational speed up to 30,000 rpm
- 3.3 V power supply
- Low power consumption. 7 mA typical.
- Extended operating temperature range (-40 °C to +125 °C)
- SMD package SSOP28

General description

The AM256L is a compact solution for angular position sensing. The IC senses the angular position of a permanent magnet placed above the chip. The permanent magnet must be diametrically polarized and of cylindrical shape.

The AM256L uses Hall sensor technology to detect the magnetic flux density distribution at the surface of the silicon. Hall sensors are placed in a circular array around the center of the IC and deliver a voltage representation of the magnetic field distribution.

The sine and cosine voltage outputs from the sensor array vary with magnet position. The sine and cosine signals are then converted to absolute angle position with a fast eight bit flash interpolator.

The absolute angle position value from the interpolator is output through a parallel binary interface or a serial SSI interface. The relative changes of the angle position are output through incremental A QUAD B encoder signals. The resolution of incremental output is selectable between 128 and 256 counts per turn with an external pin¹.

¹ For incremental output 64 counts per revolution is available by special request.

Applications

Non-contact position or velocity measurements:

- Motor motion control
- Flow measurement
- Robotics
- Camera positioning
- Front panel switches
- Workshop equipment
- Mobility aids

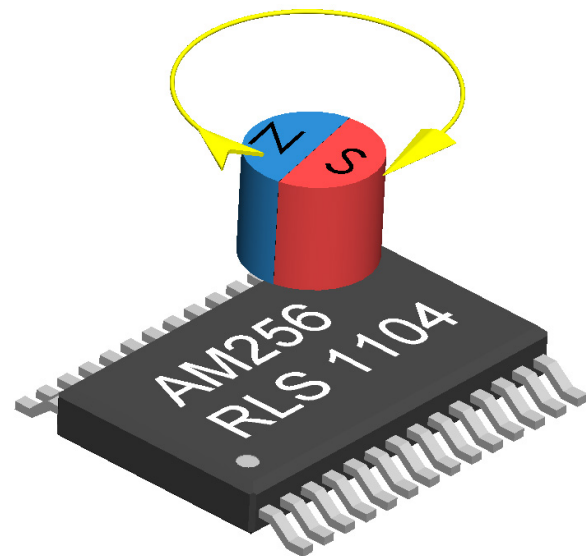


Fig. 1: AM256L with magnet

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Pin description

Pin nr.	Name	Pin description	
		PS = Low (parallel output)	PS = High (serial and incremental output)
1	Cos	Cosine analogue output for monitoring and filtering	Cosine analogue output for monitoring and filtering
2	Sin	Sine analogue output for monitoring and filtering	Sine analogue output for monitoring and filtering
3	Ihal	Input for Hall sensors bias current	Input for Hall sensors bias current
4	Iboh	Input for amplifiers bias current	Input for amplifiers bias current
5	Prog	OTP setup input * Connect to Vss	OTP setup input * Connect to Vss
6	Prg	OTP setup input * Do not connect	OTP setup input * Do not connect
7	Vdd	Power supply +3.3 V	Power supply +3.3 V
8	Vss	Power supply 0 V	Power supply 0 V
9	D7/Data	D7 (MSB) bit of parallel output	Data output for SSI
10	D6	D6 bit of parallel outputs	Must leave unconnected
11	D5/CB	D5 bit of parallel outputs	Buffered cosine output **
12	D4/SB	D4 bit of parallel outputs	Buffered sine output **
13	D3/A	D3 bit of parallel outputs	Incremental output A
14	D2/Ri	D2 bit of parallel outputs	Incremental output Ri
15	D1/B	D1 bit of parallel outputs	Incremental output B
16	D0	D0 (LSB) bit of parallel outputs	Not used, must leave unconnected
17	Vdd	Power supply +3.3 V	Power supply +3.3 V
18	DL/SR	Data Latch (High = Data latch)	Set resolution ***
19	CS	If high then outputs from pin 9 to 16 are in high impedance	If high then outputs from pin 9 to 16 are in high impedance
20	Clock	Not used, must leave unconnected	Clock input for SSI
21	Vss	Power supply 0 V	Power supply 0 V
22	Vdd	Power supply +3.3 V	Power supply +3.3 V
23	Agnd	Buffered analogue reference	Buffered analogue reference
24	Agndi	Analogue reference input	Analogue reference input
25	Vss	Power supply 0 V	Power supply 0 V
26	Vss	Power supply 0 V	Power supply 0 V
27	PS	Output mode selection	Output mode selection
28	Error	Output for monitoring	Output for monitoring
*	Each AM256L is factory optimized to achieve optimum performance. The information is stored in PROM.		
**	Buffered analogue output mode must be factory set (special order).		
***	The output resolution is selectable for incremental outputs only. When SR input is low then resolution is 64 ppr (pulses per revolution) if high then resolution is 32 ppr. The 16 ppr must be factory set (special order).		

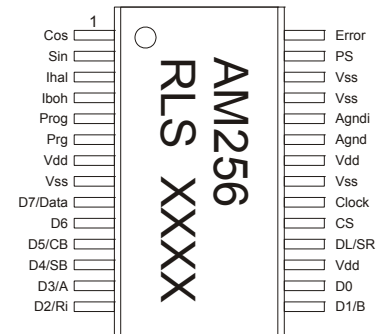


Fig. 2: Pin description

Table shows the description for each pin of the standard SSOP 28 package.

The AM256L has two output modes serial-incremental and parallel. The desired operational mode can be selected by pin PS. When the mode is changed, functions of some pins are changed.

Pins 7, 8, 17, 21, 22, 25, 26 are power supply pins. All pins must be connected.

Pins 1 and 2 are Cosine and Sine output signals for monitoring and filtering. A low-pass filter can be made with an external capacitor as there is a built-in 10 kΩ serial resistor. Recommended value for filtering is a 10 nF capacitor connected to V_{ss}. When a 10 nF capacitor is used for filtering the position information is delayed by an additional 10 μs. See the “Position delay” section on page 9 for detailed information. These outputs can be used for monitoring the signals.

Pin 3 (I_{hal}) is used to define the system sensitivity. When a resistor (R_{Ihal}) is connected from pin 3 (I_{hal}) to V_{dd} a hall sensor bias current is defined. Recommended value for R_{Ihal} is 27 kΩ. The value of R_{Ihal} can be altered to adjust the sensitivity. See the R_{Ihal}/Signal amplitude characteristic chart (Figure 25, page 16).

Pin 4 (I_{boh}) is used to define the amplifiers bias current. When a resistor (R_{Iboh}) is connected between pin 4 (I_{boh}) and V_{ss} amplifiers bias current is defined. The value R_{Iboh} must be 82 kΩ.

Pins 5 and 6 are used for OTP (One Time Programming) of the chip. The OTP is carried out at the factory and defines the behavior and accuracy of the AM256L. In operation pin 5 (Prog) must be connected to V_{ss} and pin 6 (Prg) must be unconnected.

Pins from 9 to 16 are output pins. The function of each pin is changed when the output mode is changed. See the “Pin description” table on page 3.

Pin 18 (DL/SR) is a digital input with an internal pull-down resistor. The function of the pin is changed when the output mode is changed. When parallel output mode is selected, the pin is used to latch (freeze) all 8 bits of information. When serial output mode is selected, the pin is used to select the incremental output resolution.

DL/SR	Function (parallel output mode)	Incremental output resolution (serial output mode)
Low	Parallel output is constantly refreshed	64 ppr
High	Parallel output information is latched	32 ppr

Pin 19 (CS) is a digital input with an internal pull-down resistor. When high, all digital output pins from 9 to 16 are set to high impedance mode. This function can be used when several AM256L devices are used in parallel mode. It does not affect the buffered sine cosine outputs.

Pin 20 (Clock) is a digital input for serial SSI communication. See the “Binary synchronous serial output SSI” section on page 6 for detailed information.

Pin 23 (Agnd) is a buffered analogue reference output. It is a reference voltage for analogue sinusoidal signals. It is used by the interpolator and for analogue signal outputs.

Pin 24 (Agndi) is an internally generated reference voltage. It is generated with a V_{dd}/V_{ss} resistor divider. The resistors values are 20 kΩ and 30 kΩ. The reference voltage is 1.98 V typically (3/5 of power supply voltage). Agndi must be connected to an external 100 nF capacitor. The voltage value can be changed with an external resistor if needed.

Pin 27 (PS) is a digital input pin with an internal pull-down resistor for selecting the output operation mode.

PS	Output mode
Low	Parallel output mode
High	Serial and incremental output mode

Pin 28 (Error) is an analogue output signal. It can be used for monitoring the alignment between the AM256L and the magnet. See the “Error signal” section on page 14 for detailed information.

Absolute maximum ratings

$T_A = 25\text{ }^\circ\text{C}$ unless otherwise noted

Parameter	Symbol	Min.	Max.	Unit	Note
Supply voltage	V_{dd}	-0.3	7	V	
Input pin voltage	V_{in}	-0.3	$V_{dd} + 0.7$	V	
Input current (latch-up immunity)	I_{scr}		50	mA	
Electrostatic discharge	ESD		2	kV	*
Junction temperature	T_j		160	$^\circ\text{C}$	
Storage temperature range	T_{st}	-65	170	$^\circ\text{C}$	
Humidity non-condensing	H	5	85	%	

* Human Body Model

Operating range conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Operating temperature range	T_o	-40		125	$^\circ\text{C}$	
Supply voltage	V_{dd}	3.13	3.3	3.47	V	
Supply current	I_{dd}	5	7	8	mA	*
Input frequency	f_{in}			500	kHz	**
Power-up time	t_p			10	ms	***

* Supply current is changed if some external components are changed. Typ. figure is for recommended values; it does not include output drive currents.

** Input frequency is the magnet rotational speed.

*** Time between power-on and valid output data.

Digital outputs

Parameter	Symbol	Min.	Max.	Unit	Note
High level output voltage	V_{OH}	3	V_{dd}	V	At $I_H < 1\text{ mA}$
Low level output voltage	V_{OL}	V_{ss}	0.2	V	At $I_L < 1\text{ mA}$

Digital inputs

Parameter	Symbol	Min.	Max.	Unit	Note
High level input voltage	V_{IH}	2.1	V_{dd}	V	
Low level input voltage	V_{IL}	V_{ss}	1	V	

CW or CCW rotation of the magnet

The arrow in Figure 3 shows clockwise (CW) rotation of the magnet. The picture is a top view of the magnet placed above the AM256L. CCW is counter clockwise rotation.

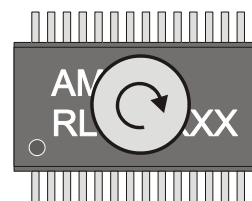


Fig. 3: CW rotation of the magnet

Binary synchronous serial output SSI

Serial output data is available in 8 bit binary code through the SSI protocol. Pin PS must be set high to activate the serial output mode.

By default, with CW rotation of the magnet the value of output data is increasing. It is possible to order an AM256L version with position increasing with CCW rotation of the magnet (special order).

Parameter	Symbol	Min.	Max.	Unit
Clock period	t_{CL}	1	20	μs
Clock high	t_{CHI}	0.5	20.5	μs
Clock low	t_{CLO}	0.5	20.5	μs
Monoflop time	t_m	21	25	μs

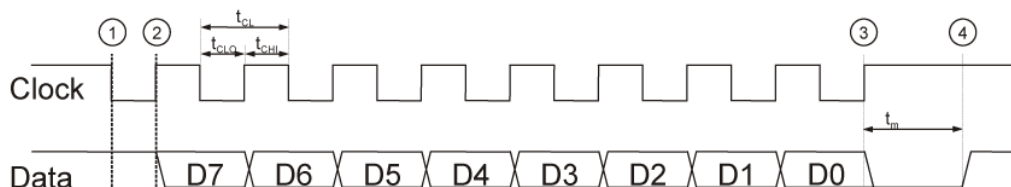


Fig. 4: SSI timing diagram

The controller interrogates the AM256L for its positional value by sending a pulse train to the *Clock* input. The *Clock* signal must always start from high. The first high/low transition (point 1) stores the current position data in a parallel/serial converter and the monoflop is triggered. With each transition of *Clock* signal (high/low or low/high) the monoflop is retriggered. At the first low/high transition (point 2) the most significant bit (MSB) of binary code is transmitted through the *Data* pin to the controller. At each subsequent low/high transition of *Clock* the next bit is transmitted to the controller. While reading the data the t_{CHI} and t_{CLO} must be less than t_{mMin} to keep the monoflop set. After the least significant bit (LSB) is output (point 3) the *Data* goes to low. The controller must wait longer than t_{mMax} before it can read updated position data. At this point the monoflop time expires and the *Data* output goes to high (point 4).

It is possible to read the same position data several times to enlarge the reliability of transmitted data. The controller must continue sending the *Clock* pulses and the same data will be output again. Between the two outputs one logic zero will be output.

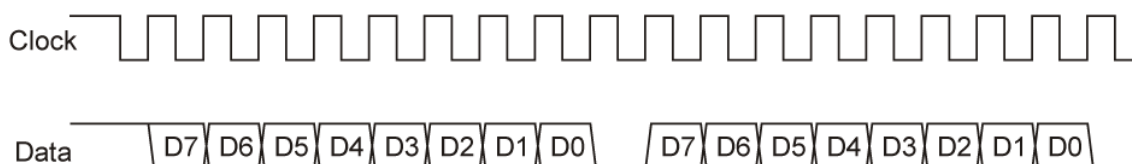


Fig. 5: SSI multi-read of the same position data

Binary parallel output

Parallel output data is available in 8 bit binary code. To activate parallel output the PS pin must be set low. Output data can be latched while reading the data.

For CW rotation of the magnet the output position is increasing. It is possible to order an AM256L version with position increasing for CCW rotation of the magnet (special order).

Incremental output

There are three signals for incremental output: A, B and Ri. Signals A and B are quadrature signals, shifted by 90°, and signal Ri is a reference mark. Three different numbers of pulses per revolution for quadrature signals are available: 64 ppr, 32 ppr (selectable with an external pin) and 16 ppr (special order). When 64 ppr is selected, the number of counts per revolution post quadrature evaluation is 256 (64 x 4 = 256). The reference mark signal is produced once per revolution. The width of the Ri pulse is 1/4 of the quadrature signal period.

Figure 6 shows the timing diagram of A, B and Ri signals with CW rotation of the magnet at 64 ppr resolution. B leads A for CW rotation of the magnet. The counting direction can be changed by swapping the A and B signals.

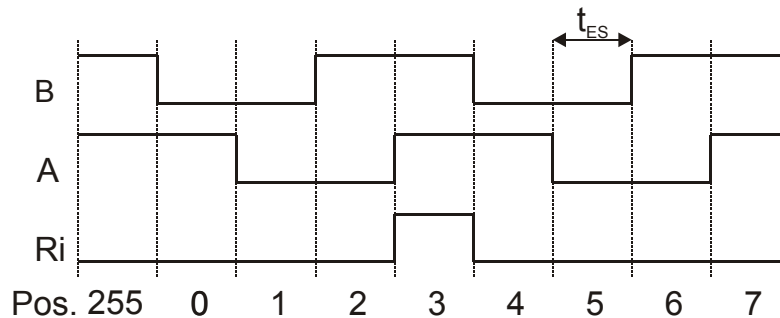


Fig. 6: Timing diagram for incremental output

Edge separation time for 64 ppr:

Parameter	Symbol	Ideal	Min.	Unit	Note
Edge separation time	t_{ES}	39	13	μs	At 6,000 rpm
Edge separation time	t_{ES}	7.8	3	μs	At 30,000 rpm

Sinusoidal analogue outputs

A_{gnd} is an internally generated reference voltage. Typical value for A_{gnd} is $3/5$ of V_{dd} (1.98 V at 3.3 V power supply). It is used as a zero level for the analogue signals and it is buffered. The internal serial impedance of the buffer for reference voltage is 60 Ω .

Pins 1 and 2 are unbuffered sinusoidal analogue outputs and they must only be used with a high impedance load.

Unbuffered sinusoidal outputs:

Parameter	Symbol	Typ.	Unit	Note
Internal serial impedance	R_n	10	$k\Omega$	
Short Circuit current	I_o	100	μA	At signal amplitude 1 V, connected to A_{gnd}

Buffered analogue outputs can be provided on pins 11 and 12 (special order). Note that it is not possible to have parallel and buffered analogue outputs at the same time.

Buffered sinusoidal outputs:

Parameter	Symbol	Typ.	Unit	Note
Internal serial impedance	R_n	800	Ω	
Short Circuit current	I_o	1.3	mA	At signal amplitude 1 V, connected to A_{gnd}

Timing diagram:

Figure 7 shows the timing diagram for CW rotation of the recommended magnet.

Sinusoidal outputs produce one period of sine and cosine signal per turn with a phase difference of 90° . Each signal has the same amplitude and minimum offset with respect to A_{gnd} .

Sinusoidal output parameters are factory optimized to achieve the best possible accuracy. However, the specified accuracy parameters are only valid for magnets specified and used within alignment tolerances. When a load is applied to the analogue outputs the amplitude is slightly reduced. The load must be the same for both channels to preserve the symmetry.

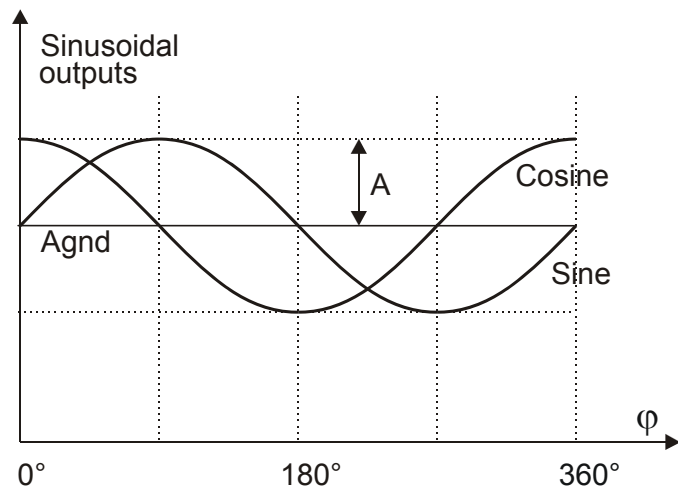


Fig. 7: Timing diagram for analogue output

Sinusoidal signal parameters:

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Amplitude	A	0.4	0.7	1.05	V	*
Amplitude difference	ΔA_{SC}			0.2	%	**
Offset Sine	V_{OSIN}			3	mV	**
Offset Cosine	V_{OCOS}			3	mV	**
Phase error	$\Delta\phi$			0.2	deg	**
Max. output frequency	f_{Max}	1			kHz	

* Amplitude = $1/2$ of peak to peak value. At $V_{dd} = 3.3$ V.

** Parameters are only valid for ideal shape and position of the magnet. Additional errors can occur if magnet setup position is not achieved. See the "Mounting instructions" section on page 12 for additional information.

Hysteresis

The AM256L uses an electrical hysteresis when converting analogue signals to digital. The hysteresis prevents the flickering of the digital output at a stationary magnet position. The effect is a position hysteresis when rotating the magnet CW or CCW.

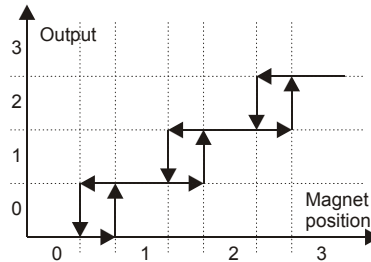


Fig. 8: Hysteresis

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Hysteresis	Hyst.	0.3	0.45	0.6	deg	

* The hysteresis depends on the signal amplitude. A higher amplitude means a lower hysteresis.

Position delay

At high rotational speed a position delay between the magnet position and the electrical output appears because of filtering. Filtering is carried out with an RC filter. The value of the resistor is 10 kΩ and the recommended value of the capacitor is 10 nF. Position delay can be calculated as follows:

$$\Delta\varphi = -\text{Arc tan}\left\{f / f_0\right\} \quad (f = \text{frequency, } f_0 = (2\pi RC)^{-1})$$

The filtering capacitor value can be reduced to 3 nF to reduce the position delay. At high rotational speed the amplitude decreases.

Parameter	Symbol	Typ.	Unit	Note
Position delay	$\Delta\varphi_{\text{pos}}$	0.36	deg	@ 10 Hz, C = 10 nF
Position delay	$\Delta\varphi_{\text{pos}}$	3.6	deg	@ 100 Hz, C = 10 nF
Position delay	$\Delta\varphi_{\text{pos}}$	0.1	deg	@ 10 Hz, C = 3 nF
Position delay	$\Delta\varphi_{\text{pos}}$	1	deg	@ 100 Hz, C = 3 nF
Amplitude decreasing	ΔA	0.2	%	@ 100 Hz, C = 10 nF
Amplitude decreasing	ΔA	15.3	%	@ 1 kHz, C = 10 nF

Nonlinearity

Nonlinearity is defined as the difference between the actual angular position of the magnet and the angular position output from the AM256L. Readings are compared at each output position change.

Integral nonlinearity is the total position error of the AM256L output. Figure 9 (page 10) shows a typical error plot if the recommended magnet is carefully positioned. Figure 10 (page 10) shows the error plot if the magnet is on the limit of alignment tolerances. Integral nonlinearity includes magnet misalignment error, differential nonlinearity and transition noise.

Differential nonlinearity is the difference between the measured position step and the ideal position step. Figure 11 (page 10) shows a typical differential nonlinearity plot. This is a function of the interpolator accuracy. Differential nonlinearity is repeatable to the transition noise if it is re-measured.

The difference between two differential measurements represents the transition noise. Transition noise is a consequence of electrical noise in the analogue signals (see Figure 12 on page 10).

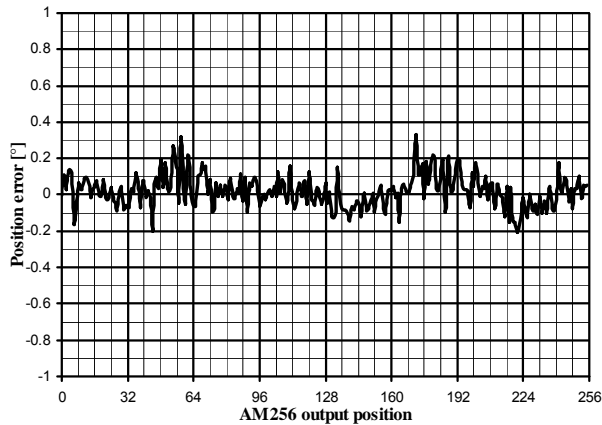


Fig. 9: Typical integral nonlinearity plot with good magnet setup

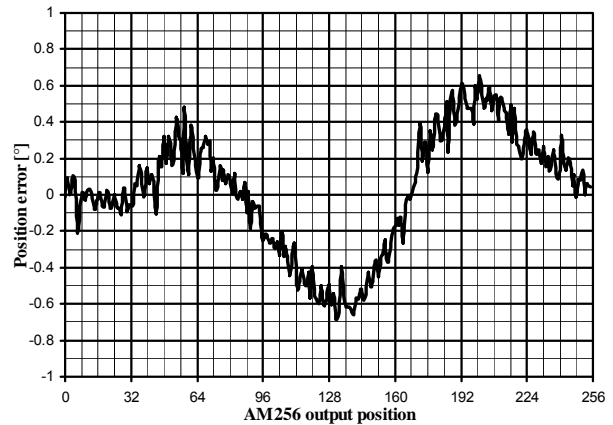


Fig. 10: Typical integral nonlinearity plot if the magnet is on the limit of alignment tolerances

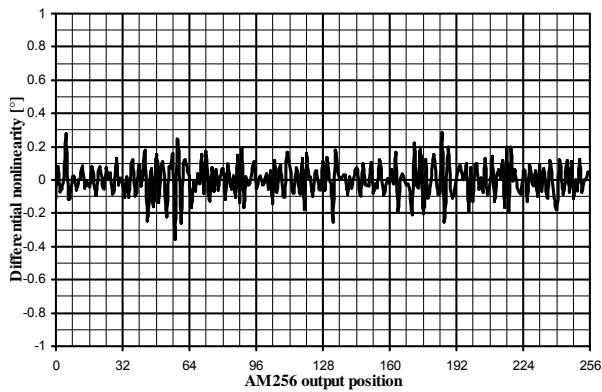


Fig. 11: Typical differential nonlinearity plot

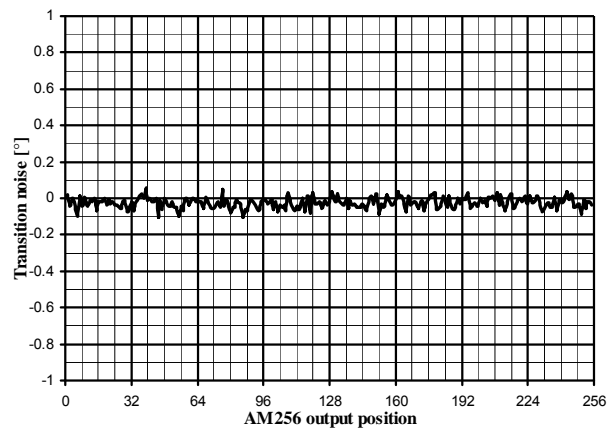


Fig. 12: Typical plot of transition noise

Parameter	Symbol	Typ.	Unit	Note
Max. integral nonlinearity	INL _{Max}	±0.6	deg	*
Max. differential nonlinearity	DNL _{Max}	±0.4	deg	0.1 deg RMS
Max. transition noise	TN _{Max}	±0.2	deg	0.03 deg RMS

* If recommended magnet is used at optimum setup position.

Recommended magnet

The AM256L can be supplied with a pre-selected magnet to ensure that optimum performance is achieved. Alternatively, magnets can be sourced from other suppliers but they must conform to the following guidelines to ensure that performance specifications can be achieved.

To select a suitable magnet it is important to know the properties of the sensors. Hall sensors are only sensitive to the perpendicular component of the magnetic flux density (B). The AM256L has a Hall sensor array arranged in a circle with a radius of 1.5 mm. Sensors are located on the surface of the silicon.

Magnets must be cylindrical in shape and diametrically polarized. The main criterion for magnet selection is the modulation of the perpendicular component of magnetic flux density at the location of the sensors (B_n).

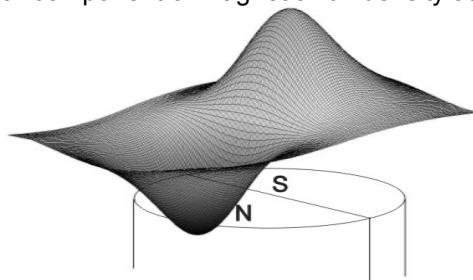


Fig. 13: Distribution of the perpendicular component of B

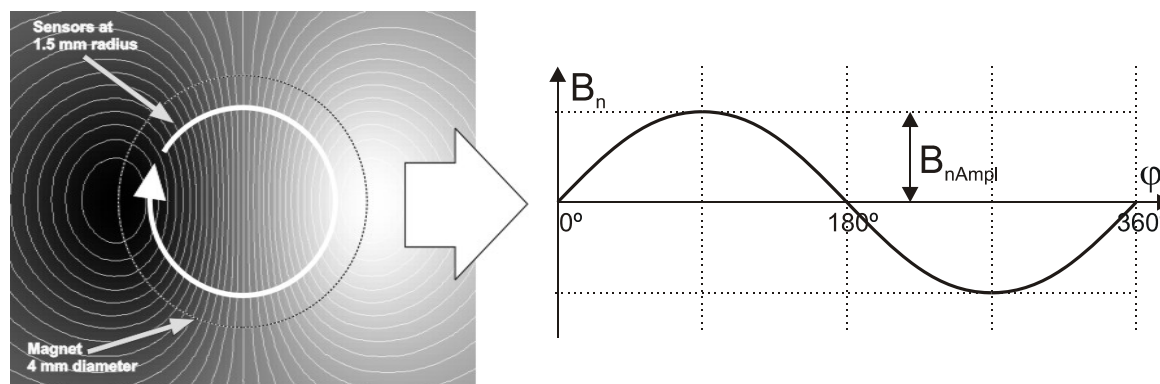


Fig. 14: Distribution of B_n and its modulation if the magnet is rotated through 360°

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Amplitude of B_n modulation	B_{nAmpl}		605		Gauss	*
Offset of B_n modulation	$B_{nOffset}$	0		±30	Gauss	**

* Typical value of B_{nAmpl} will give an analogue signal output with an amplitude of 0.7 V. The amplitude of the signal is proportional to the B_{nAmpl} . 1 Tesla equals 10,000 Gauss.

** Offset affects the integral nonlinearity if the magnet is not aligned correctly with respect to the chip.

We recommend that a magnet with the following parameters is used to provide the necessary modulation:

Parameter	Typ.	Unit	Note
Diameter	4	mm	
Length	4	mm	
Material	Sm2Co17		*
Material remanence	10.5	kGauss	
Temperature coefficient	-0.03	% / °C	
Curie temperature	720	°C	

* Rare earth material magnets SmCo are recommended; however, NdFeB magnets can be used but they have different characteristics.

Magnet position

The magnet can be placed below or above the device. The typical distance between the magnet and the sensors must be 1.6 mm for the recommended magnet.

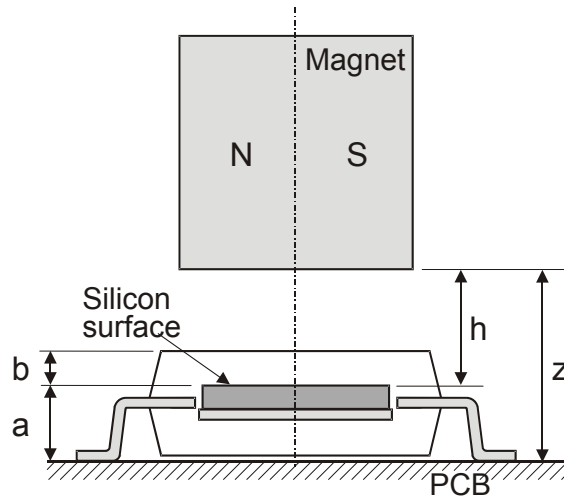


Fig. 15: Cross section of the AM256L with dimensions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Distance sensors – PCB plane	a		1.25		mm	
Distance sensors – chip surface	b		0.61		mm	
Distance sensors – magnet	h	1.4	1.60	1.8	mm	For recommended magnet
Distance magnet – PCB plane	z	2.65	2.85	3.05	mm	For recommended magnet

Mounting instructions

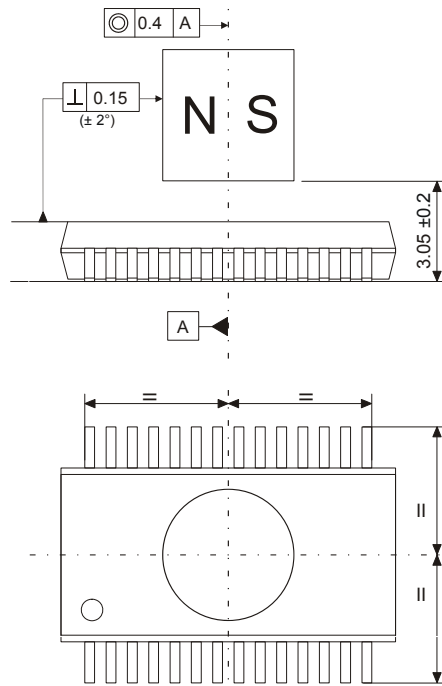


Figure 18 on page 13 shows the effect of misalignment on integral nonlinearity. The centerline of the magnet to be square to the chip within 2° and aligned with the centre of the chip within ±0.1 mm.

Fig. 16: Magnet position

Magnet quality and the nonlinearity error

Each AM256L is optimized during the production to give best performance with an ideal magnet when perfectly aligned.

An ideal magnet would have the polarization border exactly in the middle of the magnet. In reality this is impossible to achieve repeatably.

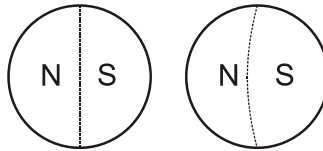


Fig. 17: Ideally polarized magnet and not ideally polarized magnet

If the polarization is not exactly in the middle of the magnet then the modulation of the magnetic field has an offset. The offset represents a mean value of B_n when the magnet is rotated through 360° and B_n is measured at 1.6 mm distance from the magnet surface and at 1.5 mm radius.

Offset will cause larger than normal integral nonlinearity errors if the AM256L placement is not in the center of the magnet rotation.

Figure 18 shows the additional integral nonlinearity error caused by misalignment of the AM256L for ideal and recommended magnets.

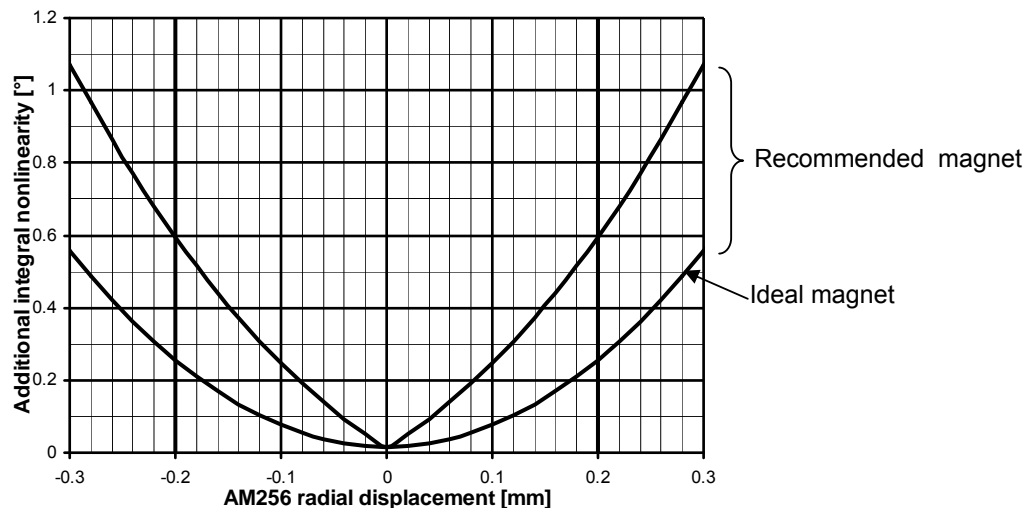


Fig. 18: Additional integral nonlinearity error caused by magnet displacement and quality

Total integral nonlinearity is the summation of integral nonlinearity and the additional integral nonlinearity error caused by magnet displacement.

Error signal

Error signal can be used for alignment of the AM256L. The error signal is sinusoidal in shape with one period per turn. The amplitude of the error signal is proportional to the AM256L displacement. To achieve optimum setup the amplitude of the error signal should be minimized.

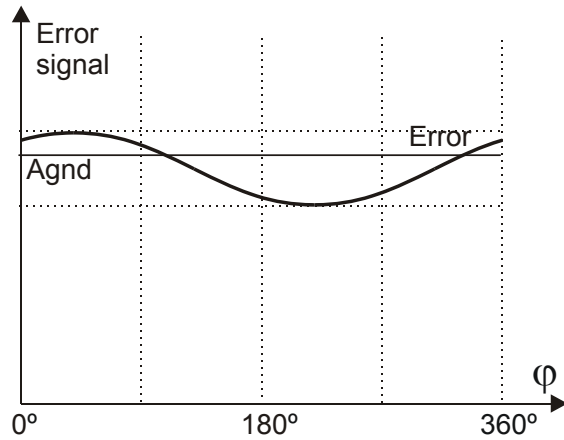


Fig. 19: Error signal shape

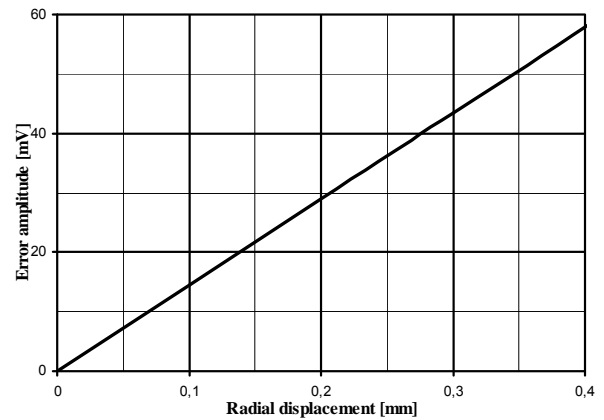


Fig. 20: Error signal amplitude

Typical applications

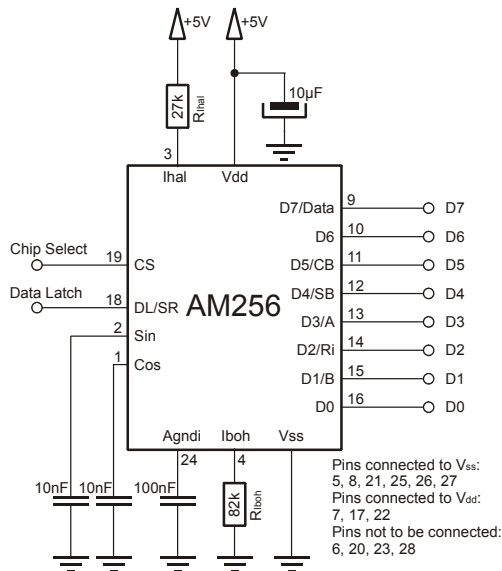


Fig. 21: Parallel output

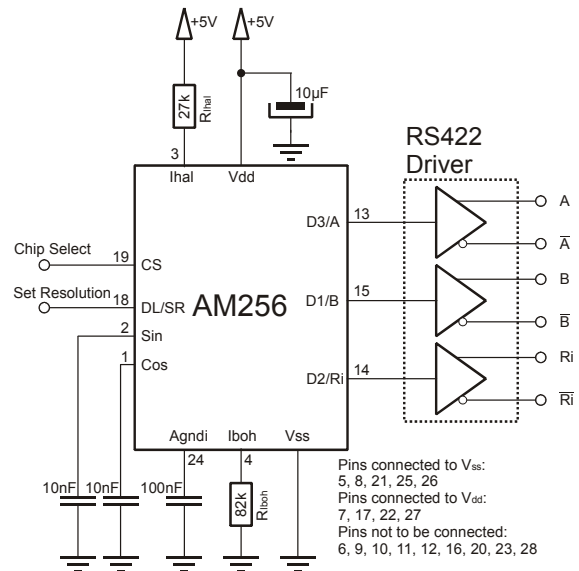


Fig. 22: Incremental output

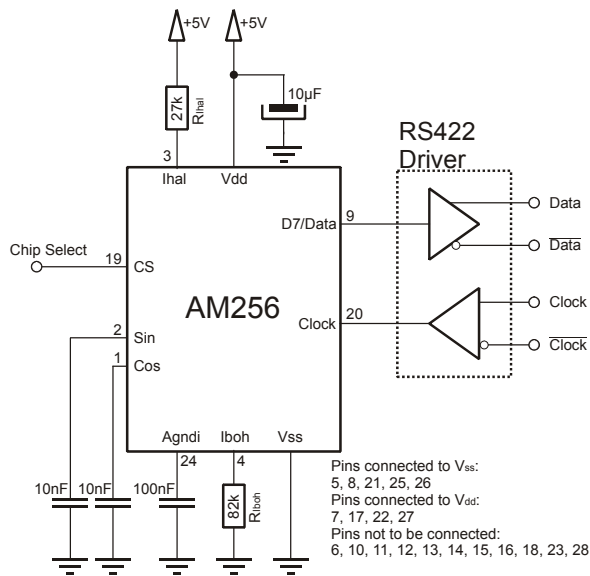


Fig. 23: SSI output

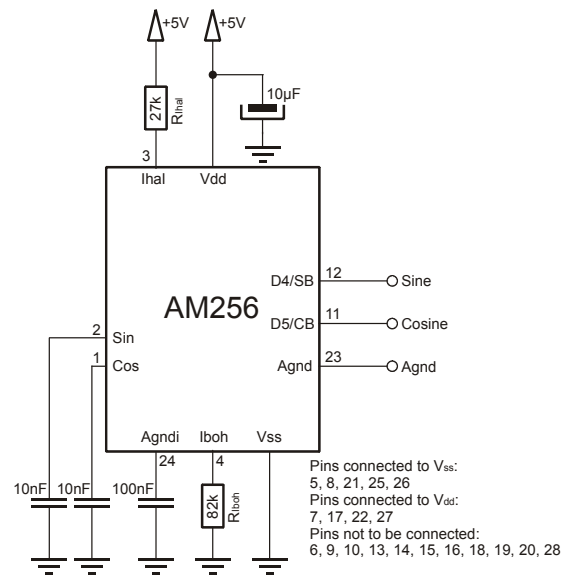


Fig. 24: Buffered analogue output
 (for AM256S only)

NOTE: Incremental and SSI outputs can be used simultaneously.

Characteristics

All characteristics are measured at recommended conditions unless otherwise stated.

Recommended conditions:

Parameter	Symbol	Value	Unit	Note
Ambient temperature	T_A	22	°C	
Distance magnet-sensors	h	1.60	mm	
Signal amplitude	A	0.7	V	<i>Min. 0.4 V, Max. 1.05 V</i>
Power supply	V_{dd}	3.3	V	
Resistor for I_{hal} setup	R_{Ihal}	27	k Ω	
Resistor for I_{boh} setup	R_{Iboh}	82	k Ω	<i>Do not change</i>
Magnet				<i>Recommended magnet</i>

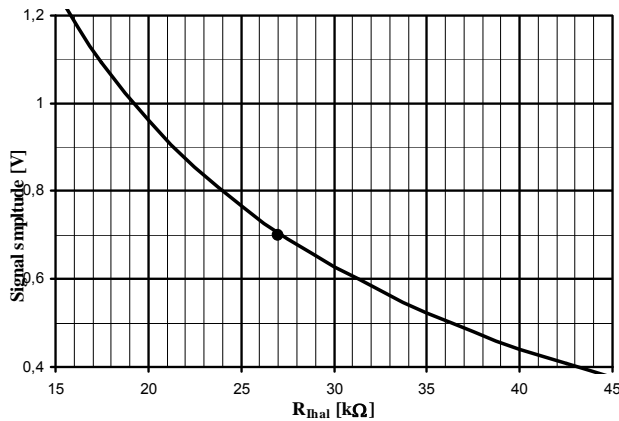


Fig. 25: Signal amplitude as a function of R_{Ihal}

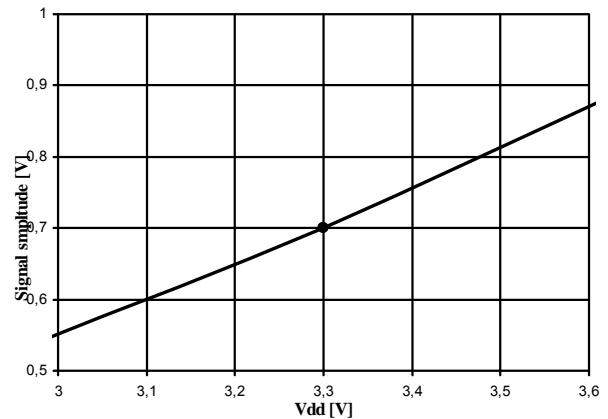


Fig. 26: Signal amplitude as a function of supply voltage

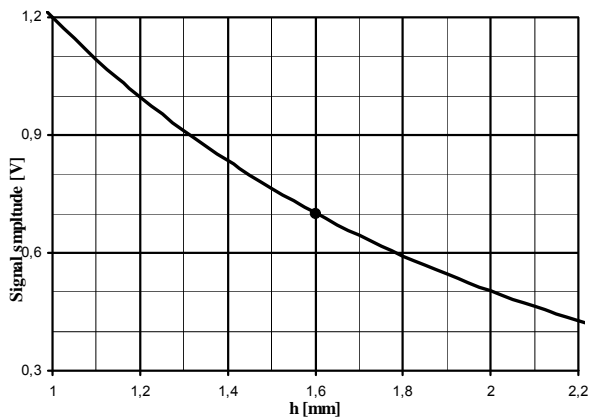


Fig. 27: Signal amplitude as a function of h

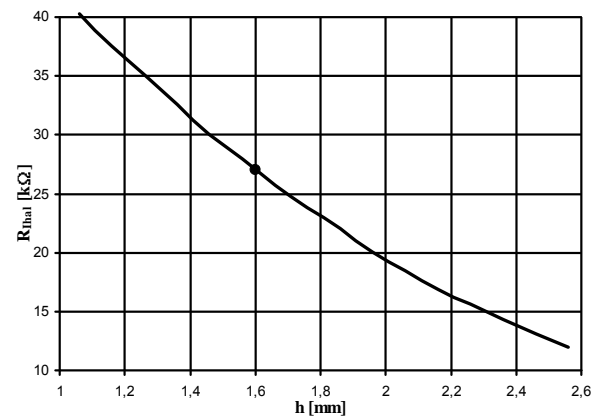


Fig. 28: R_{Ihal} to maintain signal amplitude at different h

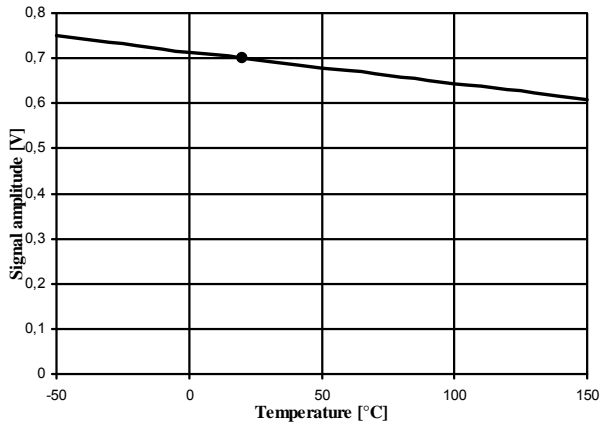


Fig. 29: Signal amplitude as a function of temperature

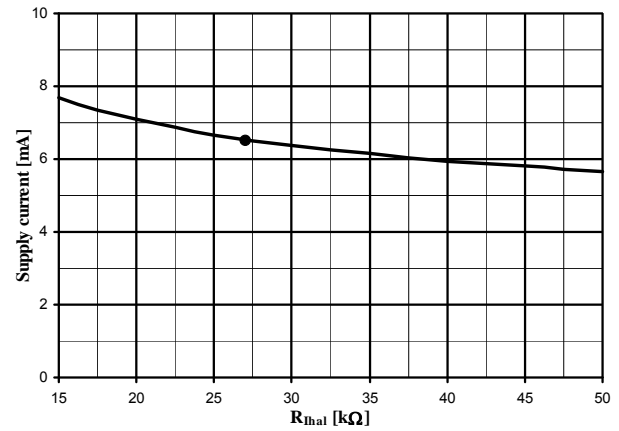
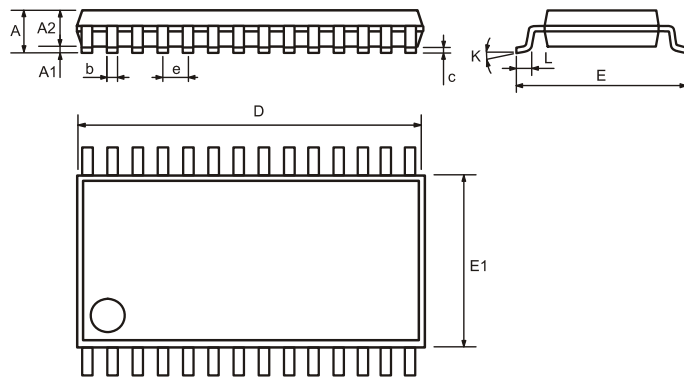


Fig. 30: Supply current as a function of R_{thal}

SSOP28 package dimensions


Dimensions:

Symbol	Min.	Typ.	Max.	Unit
A			2	mm
A1	0.05			mm
A2	1.65	1.75	1.85	mm
b	0.22		0.38	mm
c	0.09		0.25	mm
D	9.9	10.2	10.5	mm
E	7.4	7.8	8.2	mm
E1	5	5.3	5.6	mm
e		0.65		mm
K	0		10	deg
L	0.55	0.75	0.95	mm



Ordering information


1. Angular Magnetic Encoder IC

Part Number	Description
AM256LPT 	AM256L Angular Magnetic Encoder IC with default functionality Outputs: - Parallel - SSI - Incremental - Unbuffered Sine/Cosine SSOP28 plastic package Delivered in tubes (48 units per tube)

NOTE: order quantity must be a multiple of 48 (one tube).

NOTE: magnet must be ordered separately! The Angular Magnetic Encoder IC part number does not include a magnet.

2. Magnet

Part Number	Description
RMM44A2C00 	Diametrically polarized magnet Dimensions: \varnothing 4 mm x 4 mm

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Document issues

Issue	Date	Changes
02	8. 11. 2007	Changed layout Page 1: Changed the RLS colour to bright yellow Page 19: Corrected the contact information
03	14. 1. 2009	General: New layout Page 6: New SSI timing diagram

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