

Features and Benefits

- Based on advanced AMR (Anisotropic Magnetoresistive) technology, 0~360° absolute angular position sensing.
- 21-bit core angular resolution, supporting rotation speeds up to 120,000 RPM.
- Angular output latency of 2μs to 10μs.
- Provides client-side automatic non-linear calibration mode: no data interaction required, auto-calculated compensation achieving INL < ±0.07°.
- Operating temperature range: -40°C to +125°C.
- Supports incremental ABZ, incremental UVW, PWM absolute output, and 4-wire SPI bus output simultaneously.
- Incremental ABZ output supports 1 to 16,384 pulses/rev, programmable for any integer resolution.
- Incremental UVW output supports 1 to 16 pole pairs, programmable for any integer pair count.
- Built-in EEPROM programmable at 3.3V to 5.0V.

Applications

- Absolute Angle Position Sensors
- Brushless DC (BLDC) Motor Control
- Servo Motor Control
- Closed-Loop Stepper Motor Control
- Replacing Optical Encoders in various applications

General Description

MT6835 is a new generation high-speed, high-precision magnetic angle encoder IC launched by MagnTek (now part of NOVOSENSE), based on advanced Anisotropic Magnetoresistive (AMR) technology. The chip integrates two pairs of AMR Wheatstone bridges arranged at 45° relative to each other as sensing elements, along with high-performance dedicated signal processing circuitry.

When used for angle measurement, AMR devices operate in the saturation region (saturation magnetic field of 300 Gauss). In actual operation, the chip responds only to changes in the direction of the magnetic field parallel to the chip surface, independent of magnetic field strength. Therefore, MT6835 has relatively relaxed tolerances regarding magnet manufacturing variations and assembly distance variations between magnet and chip.

MT6835 provides incremental ABZ output interfaces to replace traditional optical encoders, with a maximum incremental resolution of 4,096 pulses/rev (or 16,384 steps/rev). It also supports UVW incremental output with 1 to 16 pole pair resolution.

A 4-wire SPI interface allows a host controller or MCU to read the internal 21-bit absolute angle value. Additionally, a single-wire PWM output provides 12-bit absolute angle data.

The core performance improvement of MT6835 lies in its convenient client-side self-calibration mode, which compensates for non-linearities caused by non-ideal magnets and mechanical installation offsets, thereby significantly enhancing INL performance (achieving < ±0.07°).

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1. Pin Definition

MT6835 comes in a TSSOP-16 package, available in tube (60 pcs/tube) or tape & reel (3000 pcs/reel). It is rated as Moisture Sensitivity Level 3 (MSL-3).

Magnetic Sensing Center: Located at the geometric center of the TSSOP-16 package body.

Pin Description Table

Pin No.	Pin Name	Type	Description
1	U	Digital Output	Incremental U signal or -A signal output
2	V	Digital Output	Incremental V signal or -B signal output
3	W	Digital Output	Incremental W signal or -Z signal output
4	CAL_EN	Digital Input	Client self-calibration enable control pin
5	MISO	Digital Output	SPI data bus, MT6835 uplink output data
6	MOSI	Digital Input	SPI data bus, MT6835 downlink input data
7	SCK	Digital Input	SPI clock signal
8	CSN	Digital Input	SPI chip select (active low)
9	VDD	Power	3.3V ~ 5.0V power supply
10	OUT	Digital Output	PWM output
11	TEST	Analog Input	Factory test pin (For MagnTek internal use only)
12	VSS	Ground	System Ground
13	TEST_EN	Digital Input	Factory test enable pin (For MagnTek internal use only)
14	Z	Digital Output	Incremental output Z signal (index)
15	B	Digital Output	Incremental output B signal
16	A	Digital Output	Incremental output A signal

Part Number Ordering Information

Part Number	Description
MT6835GT-STD	Standard Model
MT6835GT-M5F	AB=2500 ppr, Z=2 LSB width, UVW=5 pole pairs, maximum bandwidth configuration

2. Functional Block Diagram

MT6835 senses the orientation of the magnetic field parallel to the surface of the chip. As the magnetic field rotates, two pairs of internal AMR Wheatstone bridges produce sine and cosine analog differential signals. These signals pass through analog front-end (AFE) amplification (G) and filtering, then are converted by Analog-to-Digital Converters (ADC). The digitized sine/cosine signals enter the Digital Signal Processor (DSP) for offset compensation, phase calibration, and CORDIC angle calculation.

The calculated 21-bit absolute angle value is output via SPI or PWM interfaces, and synthesizers generate incremental ABZ or UVW signals. The IC also integrates LDO, internal oscillator (OSC), and EEPROM memory.

3. Absolute Maximum Ratings (Non-Operating Limits)

Stresses above 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 above those indicated in the operational sections is not implied.

Parameter	Min	Max	Unit	Conditions / Note
Supply Voltage (VDD)	-0.5	6.5	V	
Pin Input Voltage	-0.5	VDD	V	ABZ, UVW, SPI pins, OUT, CAL_EN, TEST pins
Pin Output Current	-20	20	mA	ABZ, UVW, OUT, MISO pins
Storage Temperature	-40	150	°C	
Latch-up Immunity	-	±100	mA	AEC-Q100-004 standard
ESD (Human Body Model - HBM)	-	±8.0	kV	AEC-Q100-002 standard
ESD (Charge Device Model - CDM)	-	±1.5	kV	AEC-Q100-011 standard

4. Operating Conditions

Parameter	Min	Max	Unit	Note
Supply Voltage (VDD)	3.0	5.5	V	3.3V ~ 5.0V typical
Magnetic Field Strength (Bpk)	30	1,000	mT	In-plane magnetic field component
Rotation Speed	-	120,000	RPM	Revolutions per minute
Operating Temperature	-40	125	°C	Ambient temperature

5. Electrical Characteristics

Unless otherwise specified, tests are performed over $VDD = 4.5V \sim 5.5V$, $Temp = -40^{\circ}C \sim 125^{\circ}C$.

General Electrical Parameters

Parameter	Description	Conditions	Min	Typ	Max	Unit
VDD	Supply Voltage	-	3.0	3.3~5.0	5.5	V
Idd	Supply Current	-	15	22	28	mA
LSB	Minimum Resolution	ABZ mode (N steps/rev)	-	360°/N	-	°
INL	Integral Non-Linearity	Factory Calibrated [1]	-	±0.5	±1.0	°
INL_CAL	Integral Non-Linearity	Client Self-Calibrated [2]	-	±0.07	-	°
DNL	Differential Non-Linearity	@2500 PPR ABZ mode	-	±0.005	-	°
TN	Transient Noise	25°C, Register BW=5	-	0.0015	-	°rms
Hyst	Hysteresis Window	Multi-step programmable	-	0.044	-	°
TPwrUp	Power-up Time	Power supply rise < 100µs	-	2	-	ms
TDelay	System Latency	Constant speed	-	10	-	µs
TST	Step Response Time	Register BW=5	-	100	-	µs

[1] Factory calibrated typical INL is measured at 25°C with no magnet misalignment. Max INL is measured across -40~125°C at max allowed airgap (AG) and max eccentricity (DISP).

[2] For details on client self-calibration, see Section 9.

Digital I/O Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Unit
VIH	Input High Voltage	CSN, MOSI, CLK, CAL_EN	0.8 * VDD	-	-	V
VIL	Input Low Voltage	CSN, MOSI, CLK, CAL_EN	-	-	0.2 * VDD	V
VOH	Output High Voltage	Push-pull (@ Iout = -2mA)	VDD - 0.4	-	-	V
VOL	Output Low Voltage	Push-pull (@ Iout = 2mA)	-	-	0.4	V
TRise / TFall	Rise / Fall Time	CL = 20pF	-	-	50	ns

ABZ & PWM Output Parameters

Parameter	Description	Min	Typ	Max	Unit
ABRES	AB Resolution (Programmable)	1	-	16,384	pulses/rev
ABFreq	A/B Output Signal Frequency	-	-	2.048	MHz
FPWM	PWM Frequency	Programmable (-8% to +8%)	497 / 994	-	Hz

EEPROM Specification

Parameter	Description	Min	Typ	Max	Unit
VDD_EE	Programming Voltage	3.0	-	5.5	V

Parameter	Description	Min	Typ	Max	Unit
Endurance	Erase / Write Cycles	1,000	-	-	cycles
Retention	Data Retention (@ 150°C)	10	-	-	years

6. Magnetic Field Parameters

Over VDD = 3.0 ~ 5.5V, Temp = -40 ~ 125°C, using 1 pole-pair radially magnetized cylindrical magnet.

Parameter	Description	Min	Typ	Max	Unit
Dmag	Recommended Magnet Diameter	-	10.0	-	mm
Tmag	Recommended Magnet Thickness	-	2.5	-	mm
Bpk	In-Plane Magnetic Field Strength	30	-	1,000	mT
AG	Airgap (Magnet surface to IC surface)	-	1.0	3.0	mm
RS	Rotation Speed	-	-	120,000	RPM
DISP	Installation Eccentricity / Off-axis	-	-	0.3	mm
TCmag1	Temp Coefficient (NdFeB Magnet)	-	-0.12	-	%/°C
TCmag2	Temp Coefficient (SmCo Magnet)	-	-0.035	-	%/°C

7. Output Modes & Interfaces

7.1 I/O Pin Configuration

Pin No.	UVW + SPI + PWM + ABZ Configuration	-A / -B / -Z + SPI + PWM + ABZ Configuration
1	U	-A
2	V	-B
3	W	-Z
5, 6, 7, 8	SPI (MISO, MOSI, SCK, CSN)	SPI (MISO, MOSI, SCK, CSN)
10	OUT (PWM)	OUT (PWM)
14, 15, 16	Z, B, A	Z, B, A

7.2 Reference Circuit

The MT6835 is powered by a single 3.3V~5.0V supply. A decoupling capacitor of at least 0.1μF between VDD and VSS is required close to the chip. For enhanced EMC performance, a TVS diode (6V) across VDD/VSS is strongly recommended. Pins CAL_EN (Pin 4) and TEST (Pin 13) feature internal 250kΩ pull-down resistors.

7.3 Quadrature ABZ Output Mode

When rotating counter-clockwise (CCW, looking down at the chip top surface), signal B leads signal A by 90° (1/4 period). When rotating clockwise (CW), signal A leads signal B by 90°. The Z pulse represents the 0° absolute angle position. Upon power-up, ABZ outputs remain inactive for 64ms while internal stabilization completes.

Rotation Direction Register: ROT_DIR (EEPROM Address 0x00D)

Value	Direction	AB Relationship
0x0 (Default)	Counter-Clockwise (CCW)	B leads A
0x1	Clockwise (CW)	A leads B

ABZ Resolution Register: ABZ_RES[13:0] (EEPROM 0x007 ~ 0x008)

Supports 1 to 16,384 pulses per revolution (PPR) user programmable for any integer value.

- **0x0000:** 1 PPR
- **0x0001:** 2 PPR
- **0x3FFF:** 16,384 PPR (Maximum = 65,536 steps/rev)

Z Pulse Width Register: Z_PUL_WID[2:0] (EEPROM 0x00A)

Value	Width	Value	Width
0x0	1 LSB	0x4	16 LSBs
0x1	2 LSBs	0x5	60°
0x2	4 LSBs	0x6	120°
0x3	8 LSBs	0x7	180°

7.4 UVW Output Mode

Provides 120° phase-shifted U, V, W signals replacing traditional Hall sensors for BLDC motor commutation. User programmable from 1 to 16 pole pairs per revolution via register UVW_RES[3:0] (EEPROM 0x00B).

7.5 PWM Output Mode

Provides 12-bit absolute angle or speed output on Pin 10. Frame period is 4,119 clock cycles (16 clocks high start bit, 4,095 clocks angle data, 8 clocks low stop bit). Frequency selectable between 994 Hz (default) and 497 Hz via PWM_FQ. Data type selected via PWM_SEL [2:0] (0x0 = 12-bit Angle, 0x2 = 12-bit Speed).

7.6 SPI Interface Protocol

MT6835 uses SPI Mode 3 (CPOL=1, CPHA=1). Max SPI clock frequency is 16 MHz. Communication begins on CSN falling edge and ends on CSN rising edge. Data is sampled on SCK rising edge.

SPI Command Codes (C3 ~ C0)

Command Code	Operation	Description
0011 (0x3)	Read Register	Read single byte from specified address
0110 (0x6)	Write Register	Write single byte to specified address
1100 (0xC)	Program EEPROM	Burn current register values into non-volatile EEPROM (Returns 0x55 ACK)
0101 (0x5)	Auto Zero Set	Sets current position as zero angle in register (Returns 0x55 ACK)
1010 (0xA)	Burst Read Angle	Continuously read angle registers (0x003~0x006)

Angle Reading Format (Registers 0x003 ~ 0x006)

When CSN goes low, current 21-bit angle data is latched into registers 0x003 ~ 0x005:

- **0x003:** ANGLE[20:13] (High 8 bits)
- **0x004:** ANGLE[12:5] (Middle 8 bits)
- **0x005:** ANGLE[4:0] (Low 5 bits) + STATUS[2:0] (3 bits)
- **0x006:** CRC[7:0] (Polynomial: $X^8 + X^2 + X + 1$)

Angle Calculation Formula:

$$\text{Angle } (^{\circ}) = (\text{ANGLE}[20:0] / 2^{21}) \times 360^{\circ}$$

Status Warning Bits (STATUS[2:0])

- **STATUS[0]:** Over-speed alarm (> 120,000 RPM) — '1' = Warning
- **STATUS[1]:** Magnetic field weak alarm — '1' = Warning
- **STATUS[2]:** Power supply undervoltage alarm — '1' = Warning

8. Zero Position Programming

Zero point can be configured automatically using SPI command 0101 or calculated manually and written to ZERO_POS[11:0] (Address 0x009~0x00A). After zero setting, send EEPROM Program command 1100 and wait at least 6 seconds before powering off.

9. Calibration Mechanisms

MT6835 features a 3-layer calibration architecture:

1. **Factory Base Calibration:** Performed by MagnTek during chip production, trimming amplitude, offset, and phase errors to achieve $\text{INL} < \pm 0.5^{\circ}$.
2. **Client Self-Calibration:** Executed after system assembly. Drive the motor at a constant speed (configured by AUTO_CAL_FREQ[2:0]), pull CAL_EN (Pin 4) HIGH, and rotate for >64 revolutions. The IC auto-calculates compensation parameters and writes them to EEPROM, reducing INL to $< \pm 0.07^{\circ}$.
3. **Client Non-Linearity Calibration (NLC):** Uses a 256-point lookup table stored in EEPROM, calibrated against a high-precision optical reference encoder (>21-bit).

10. Register Map

Address	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Type
0x001	USER_ID[7:0]								EEPROM
0x003	ANGLE[20:13]								Read-only
0x004	ANGLE[12:5]								Read-only
0x005	ANGLE[4:0]					STATUS[2:0]			Read-only
0x006	CRC[7:0]								Read-only
0x007	ABZ_RES[13:6]								EEPROM
0x008	ABZ_RES[5:0]						ABZ_OFF	AB_SWAP	EEPROM
0x009	ZERO_POS[11:4]								EEPROM
0x00A	ZERO_POS[3:0]				Z_EDGE	Z_PUL_WID[2:0]			EEPROM
0x00B	Z_PHASE[1:0]		UVW_MUX	UVW_OFF	UVW_RES[3:0]				EEPROM
0x00C	Reserved	NLC_EN	PWM_FQ	PWM_POL	Reserved	PWM_SEL[2:0]			EEPROM
0x00D	Reserved	ROT_DIR	HYST[2:0]			Reserved			EEPROM
0x00E	GPIO_DS	AUTOCAL_FREQ[2:0]			Reserved				EEPROM
0x011	Reserved					BW[2:0]			EEPROM
0x013~0x0D2	NLC Byte 0x00 ~ 0xBF (Total 192 Bytes LUT)								EEPROM

11. Mechanical & Installation Guidelines

The magnet center must be aligned with the magnetic sensing center (geometric center of the package). Off-axis eccentricity (DISP) and large airgap (AG) introduce harmonic non-linearities. Client self-calibration or NLC calibration should be performed after mechanical mounting.

13. Package Dimensions (TSSOP-16)

Symbol	Min (mm)	Max (mm)	Min (inch)	Max (inch)
D	4.900	5.100	0.193	0.201
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
e	0.650 BSC		0.026 BSC	
A	-	1.200	-	0.047
A2	0.800	1.000	0.031	0.039

15. Revision History

Revision	Date	Description
0.5	2021.01	Initial draft release (Preliminary)

Revision	Date	Description
1.0	2021.04	Official release
1.1	2022.02	Updated Fig-24 timing diagram, increased max AB frequency
1.2	2022.05	Updated Sections 7.6.7 and 7.6.8, updated part numbers
1.3	2022.12	Updated default Hysteresis to 0.011°, updated Fig-7 and Sec 7.6.2