TMR4101

High Precision Analog Magnetic Scale Sensor

Description

The TMR4101 magnetic scale sensor contains two push-pull half-bridges, each consisting of two high-sensitivity tunnel magnetoresistance (TMR) elements. The layout of the TMR elements matches the width of the magnetic poles. When the sensor moves along the length of the scale, the sensor outputs two quadrature sine wave signals, each corresponding to the width of a pair of magnetic poles. By decoding these two sine wave signals, the relative displacement between the chip and the scale can be accurately measured.

The TMR4101 magnetic scale sensor chip uses a small package DFN4L (1.32 mm × 0.66 mm × 0.3 mm), which reduces the requirements for chip installation, making the structural design of the system more flexible and convenient for assembly in narrow spaces.

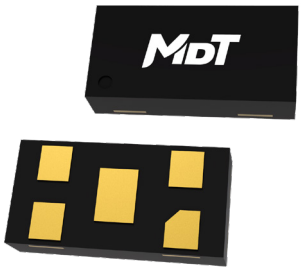
MultiDimension Technology can provide magnetic scale medium with customizable lengths as the accessory of TMR4101 to meet our customers' needs.

Features and Benefits

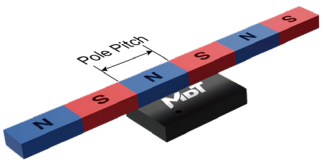
- Tunneling magnetoresistance (TMR) technology
- Detects magnetic scale period of 0.8 mm
- High sensitivity
- Wide operating voltage range
- Allows for larger air gap
- Analog voltage outputs for A and B phases
- Good temperature stability
- RoHS & REACH compliant

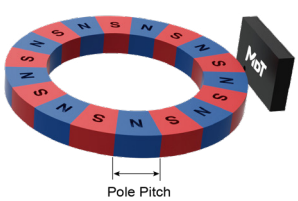
Applications

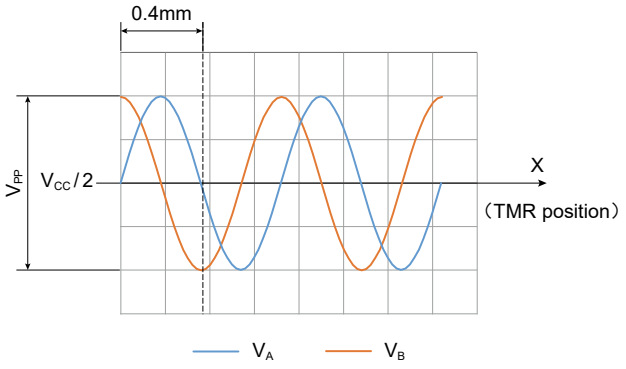
- Camera autofocus system
- Gear motion speed and direction detection
- Linear and angular velocity sensing
- Linear and curved displacement measurement
- Magnetic scale and magnetic encoder



DFN4L







Dual-phase signal output (V_A, V_B)

Selection Guide of Sensor

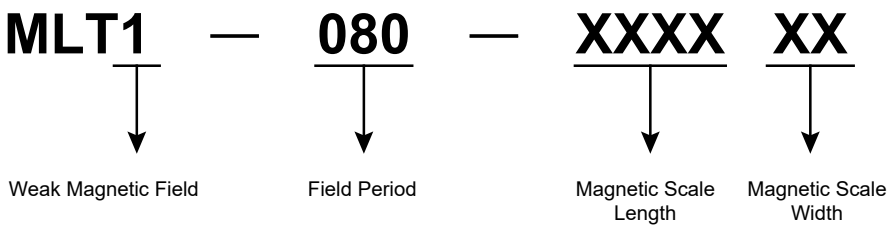
Part Number	Output	Supply Voltage	Operating Temperature	Package	Packing Form
TMR4101D	Analog	1 V to 6 V	-30 °C to 90°C	DFN4L	Tape & Reel

Selection Guide of Magnetic Scale

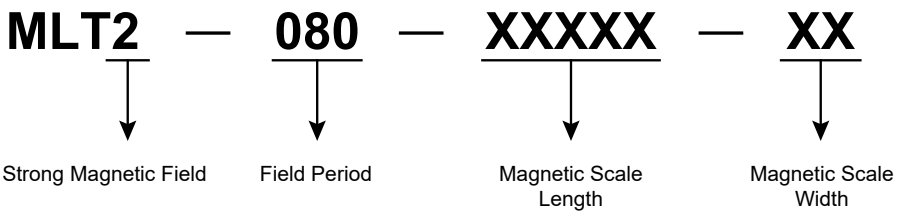
Part Number*	Magnetic Flux Density	Pole Pitch	Packing Form
MLT1080-XXXXXX	Weak Magnetic Field	0.4 mm	Tray
MLT2080-XXXXX-XX	Strong Magnetic Field	0.4 mm	Tray

*Note: The length of the magnetic scale can be customized. Please contact local MDT sales representatives for more details.

MLT1080 Magnetic Scale Model Description



MLT2080 Magnetic Scale Model Description



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1. Functional Block Diagram

The sensor contains two sets of push-pull half-bridge structures composed of tunnel magnetoresistance (TMR) elements. The internal electrical connections of the chip are shown in Figure 1.

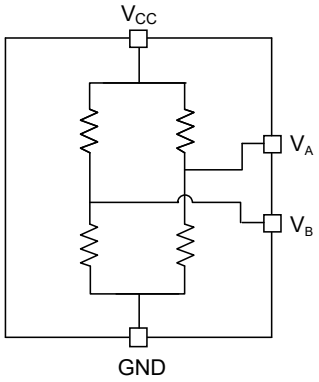

Figure 1. Functional block diagram

2. Operating Principle

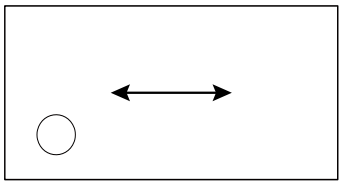

Figure 2. Sensing direction of TMR4101

As shown in Figure 2, the sensing direction of the sensor is parallel to the X-axis of the surface where the package laser mark is located. When the sensor moves relative to the scale along the X-axis direction, the resistance value of each TMR element changes periodically due to the periodic variation in the magnetic field magnitude at the position of each TMR element. This change leads to the periodic variation of the output signal, as shown in Figure 3.

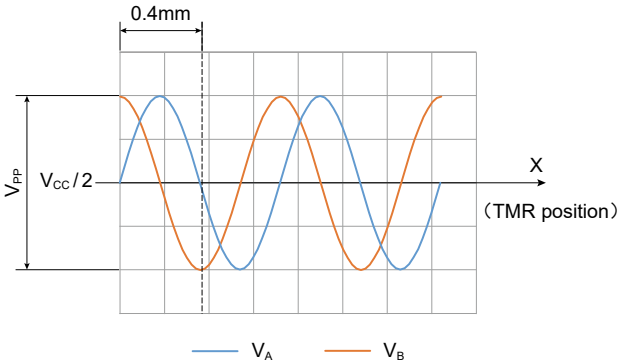

Figure 3. Dual-phase signal output (V_A, V_B)

3. Pin Configuration

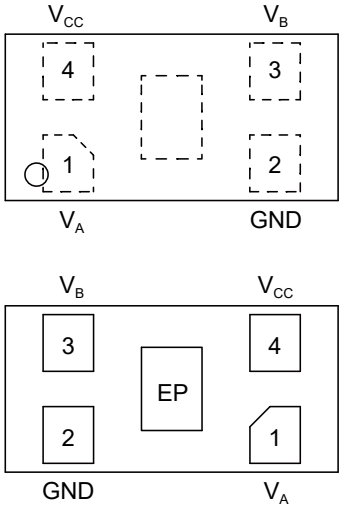

Figure 4. Pin configuration (DFN4L)

Pin Number	Name	Function
1	V_A	Phase A output
2	GND	Ground
3	V_B	Phase B output
4	V_{CC}	Supply voltage
-	EP	Soldering pad

4. Absolute Maximum Ratings of Sensor

Parameters	Symbol	Min.	Max.	Unit
Supply voltage	V_{CC}	-	6.5	V
ESD performance (HBM)	$V_{ESD(HBM)}$	-	1.5	kV
ESD performance (CDM)	$V_{ESD(CDM)}$	-	500	V
Operating ambient temperature	T_A	-30	90	°C
Storage ambient temperature	T_{STG}	-40	125	°C

5. Absolute Maximum Ratings of Magnetic Scale

Parameters	Symbol	Min.	Max.	Unit
Operating ambient temperature	T_A	-30	90	°C
Storage ambient temperature	T_{STG}	-40	90	°C

Note: The maximum value parameters in the limit parameters are only to ensure that the chip and accessories will not be permanently damaged. For normal operating conditions, please refer to the electrical performance parameters and magnetic performance parameter tables.

6. Electrical Specifications of Sensor

V_{CC} = 1.0 V, T_A = 25 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}	-	-	1	6	V
Bridge resistance	R_B	B = 0 Gs	5	-	10	kΩ
Magnetoresistance ratio	MR	-	20	35	50	%
Phase A signal offset drift	$V_{OFFSETA}$	B = 0 Gs	-10	0	10	mV/V
Phase B signal offset drift	$V_{OFFSETB}$	B = 0 Gs	-10	0	10	mV/V
Differential signal offset drift	$V_{OFFSETA-B}$	B = 0 Gs	-10	-	10	mV/V
Temperature coefficient of bridge resistance	TCR_B	-30 °C to 90 °C	-	-0.06	-	%/°C
Temperature coefficient of magnetoresistance ratio	TC_{MR}	-30 °C to 90 °C	-	-0.1	-	%/°C
Temperature coefficient of offset	TC_{OFF}	-30 °C to 90 °C	-	0	-	mV/°C

7. Electrical Specifications of Magnetic Scale

Air gap = 0.15 mm, V_{CC} = 1.0 V, T_A = 25 °C

Parameter	Symbol	Min.	Typ.	Max.	Unit
MLT1080 Peak to peak output	V_{PP1}	120	160	200	mV
MLT2080 Peak to peak output	V_{PP2}	180	230	280	mV
Peak fluctuation	$V_{PEAK\ FLUCTUATION}$	-	-	20	mV
Valley fluctuation	$V_{VALLEY\ FLUCTUATION}$	-	-	20	mV

8. Magnetic Specifications of Sensor

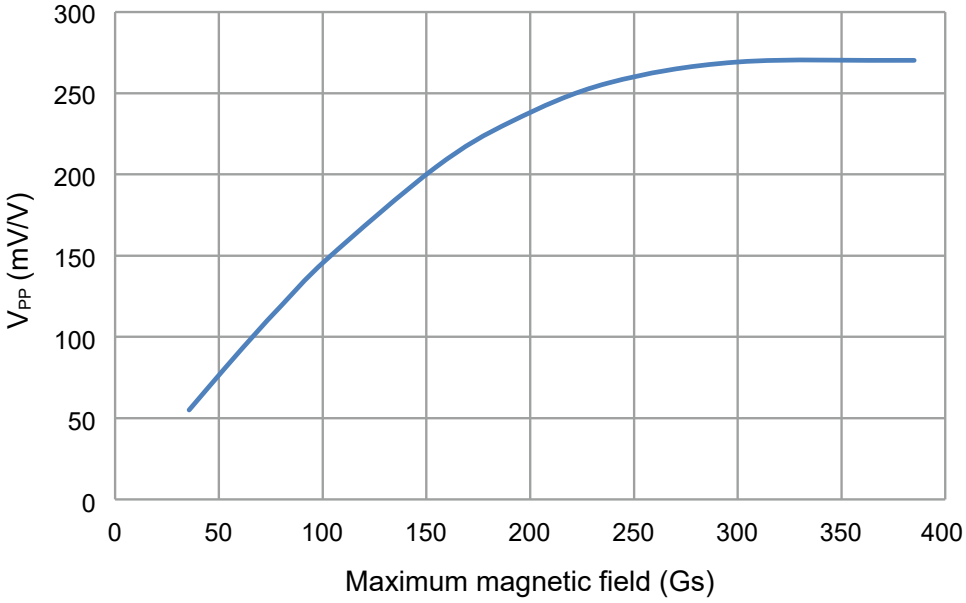

Figure 5. V_{PP} versus maximum magnetic field

Note:

1) 1 Gauss = 0.1 millitesla = 79.8 A/m

2) Magnetic pole pitch = 0.4 mm

9. Magnetic Specifications of Magnetic Scale

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Coercivity	BHC	T_A = 25 ºC	145	160	175	kA/m

10. Specifications Definition of Sensor

10.1 Bridge resistance R_B

Resistance between V_{CC} and GND, this value can be customized according to customer specifications.

10.2 Magnetoresistance ratio MR

$$MR = \frac{R_2 - R_1}{R_1}$$

R_1: The value of R_B at +75 Gs

R_2: The value of R_B at -75 Gs

10.3 Drift of zero-point offset V_{OFFSET}

$$V_{OFFSETA} = \frac{V_{A0} - V_{CC}/2}{V_{CC}} \qquad V_{OFFSETB} = \frac{V_{B0} - V_{CC}/2}{V_{CC}}$$

V_{A0}: Output voltage of phase A at 0 Gs

V_{B0}: Output voltage of phase B at 0 Gs

10.4 Drift of zero-point differential output $V_{OFFSETA-B}$

$$V_{OFFSETA-B} = V_{OFFSETA} - V_{OFFSETB}$$

10.5 Temperature coefficient of bridge resistance TCR_B

$$TCR_B = \frac{R_B(T2) - R_B(T1)}{R_B(25°C) \times (T2-T1)} \times 100\% \qquad T1 = T_A(Min) = -30°C,\ T2 = T_A(Max) = 90°C$$

10.6 Temperature coefficient of magnetoresistance ratio TC_{MR}

$$TC_{MR} = \frac{MR(T2) - MR(T1)}{MR(25°C) \times (T2-T1)} \times 100\% \qquad T1 = T_A(Min) = -30°C,\ T2 = T_A(Max) = 90°C$$

10.7 Temperature coefficient of offset TC_{OFF}

$$TC_{OFF} = \frac{V_{OFFSET}(T2) - V_{OFFSET}(T1)}{T2-T1} \qquad T1 = T_A(Min) = -30°C,\ T2 = T_A(Max) = 90°C$$

11. Specifications Definition of Magnetic Scale

The magnetic scale medium of TMR4101 consists multiple pairs of magnetic poles (T1, T2, ...), and the length of the pole pitch is 0.8 mm.

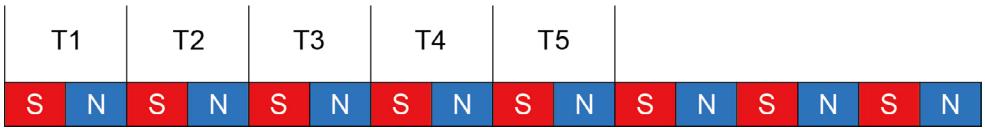

Figure 6. Illustration of magnetic scale pole pitch

The output signal of TMR4101 is as shown in Figure 7, when the sensor works with the magnetic scales:

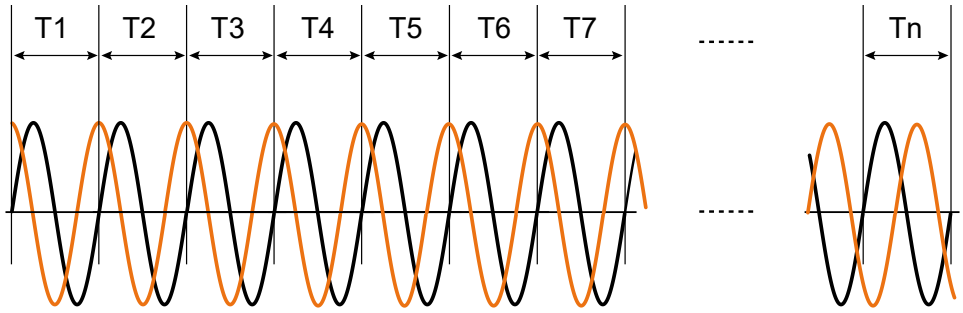

Figure 7. Output signal of TMR4101 when it works with magnetic scale

12. DFN4L Package

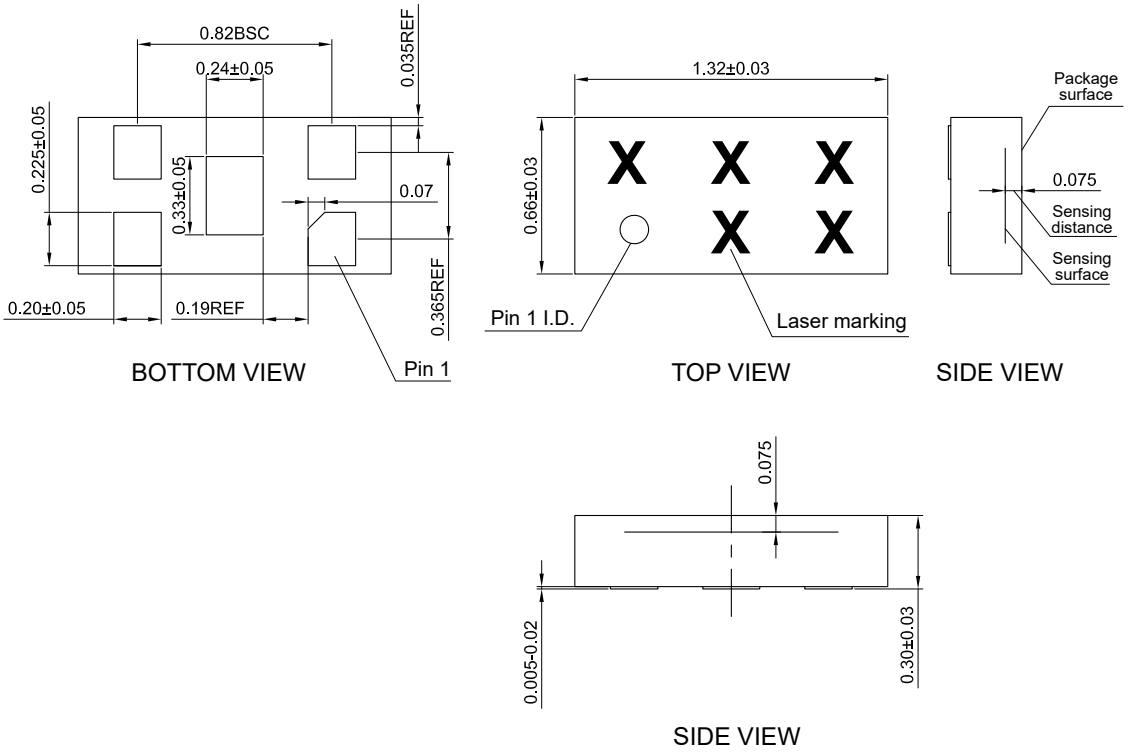

Figure 8. Package outline of DFN4L (unit: mm)

13. Dimension of Magnetic Scale

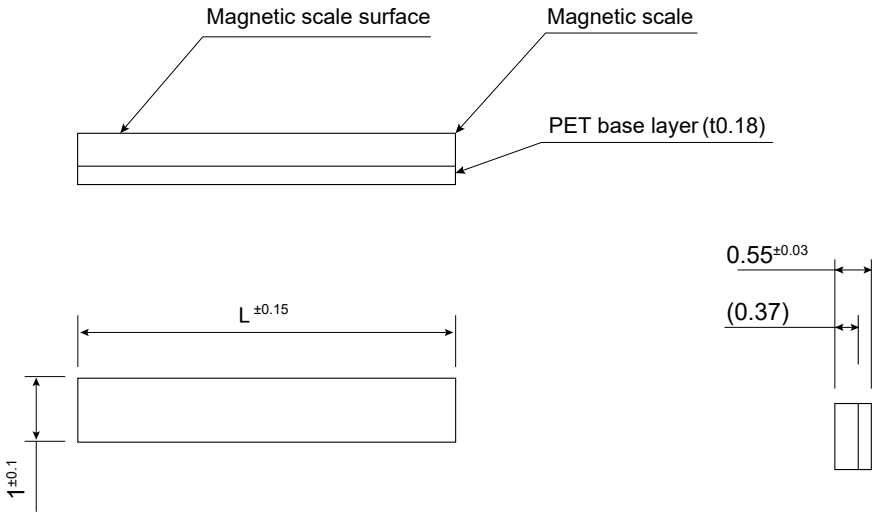

Figure 9: Dimension of magnetic scale (unit: mm)

Note:

L：The magnetic scale length can be customized according to customer requirements.

14. Packing of Sensor Chip

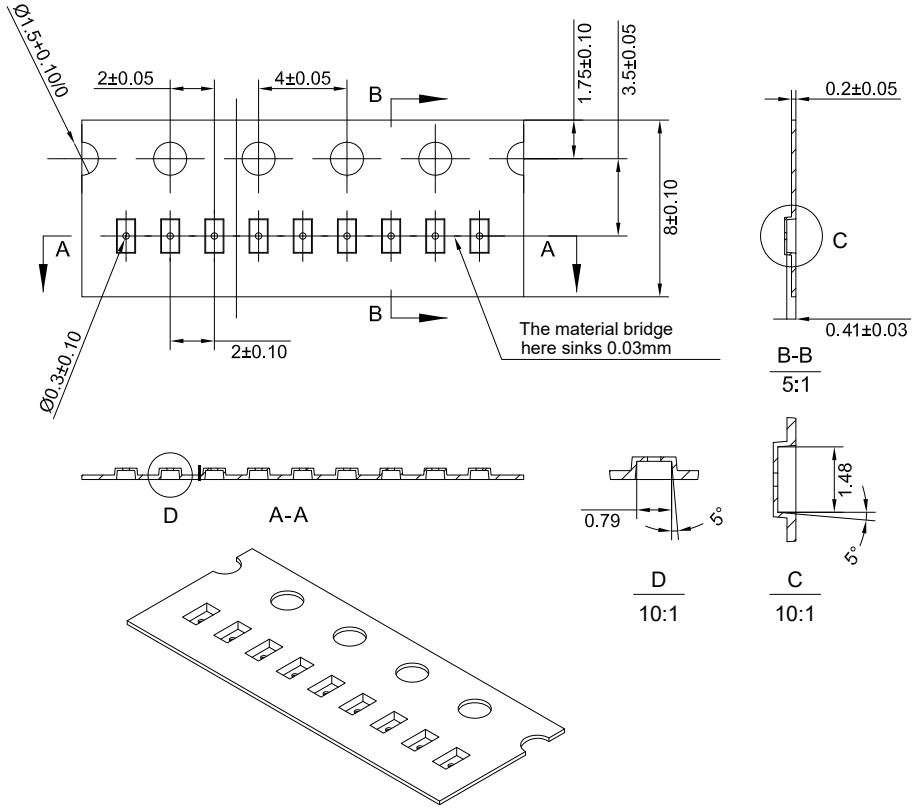

Figure 10. Sensor chip carrying tape and reel (unit: mm)

15. Taping Orientation of Sensor Chip

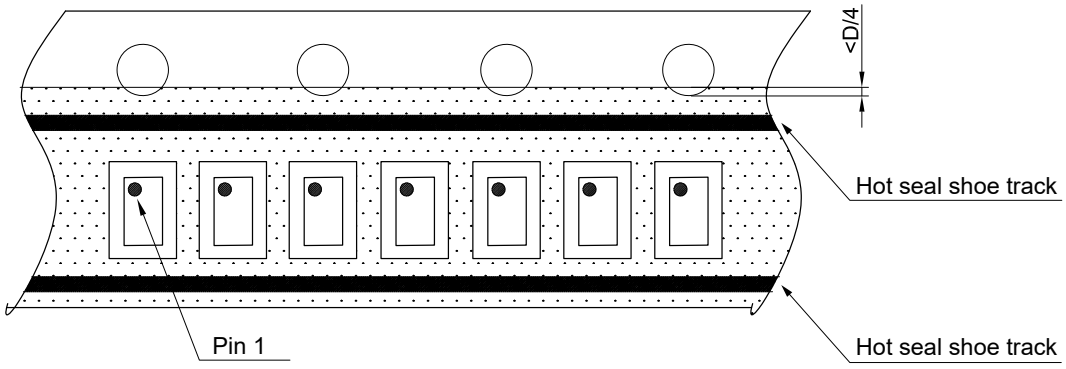

Figure 11. Orientation of sensor chip

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