TDK Nivio xMR Sensor Datasheet rev.5

1. Summary

The Nivio xMR sensor is designed to measure very low ac magnetic field of a few 10pTlevel by using the recommended circuit. The MR spin valve element contains a feature of smaller resistance change along with higher temperature. In order to structure a closed loop current circuit, a coil is used inside the Nivio xMR sensor. It enables to compensate its sensitivity variation along with temperature change. This temperature compensation is effective on ac magnetic field measurement. However, it is non-functional on dc magnetic field measurement. We hereby recommend circuit structure, which eliminates dc magnetic field signal on this sensor.

1-1. What is MR spin valve element

The Nivio xMR sensor uses MR spin valve elements in order to realize high sensitivity magnetic field measurements. The MR spin valve element is made of sandwich structure which non-magnetic layer is placed between magnetic layers. One magnetic layer is magnetically pinned layer. The other magnetic layer is the free layer which aligns to external magnetic fields. Since impedance of elements changes proportionally against relative angle of magnetic field of pinned layer and free layer, it enables to measure field intensity from voltage.

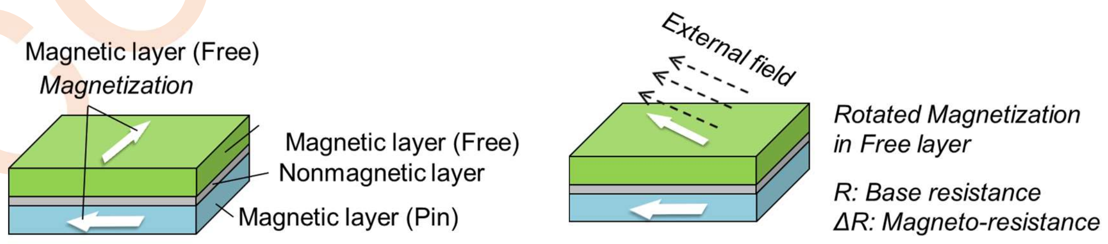


Fig. 1: Example of the MR spin valve elements structure (left) and rotation of free layer by external field (right).

1-2. Bridge structure and compensation coil using spin valve element

The Nivio xMR sensor is structured with Wheatstone bridge which is made out of four MR spin valve elements. Figure 2 shows general Wheatstone bridge circuit structured with combination of four elements. The arrows show the direction of field in pinned layer. When an external magnetic field is applied, differential output between Va-Vb will be $(\Delta R/R)\cdot V_{dd}$. The resistance change against magnetic field of MR enables to obtain output voltages which are proportional to MR comparison and input voltage. Focusing on differential output (Va-Vb) of Wheatstone bridge, it enables to ignore the influence of common mode noise which is input from V_{dd} and measure magnetic field with high sensitivity. Furthermore, Fig. 3 shows that the Nivio xMR sensor mentioned 1-2 is structured with bridge structure and compensation coil. Using the closed loop current circuit (recommended circuit) with the compensation coil, it reserves high sensitivity, broad linearity, and excellent thermal property.

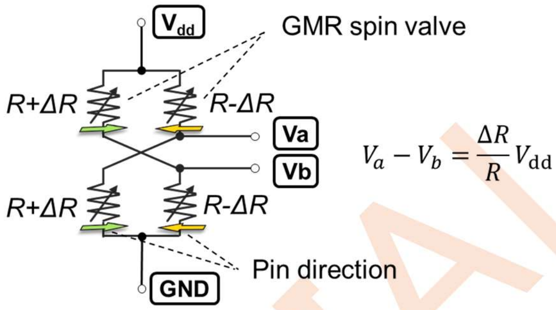


Fig. 2: Bridge structure and sensor output using MR element.

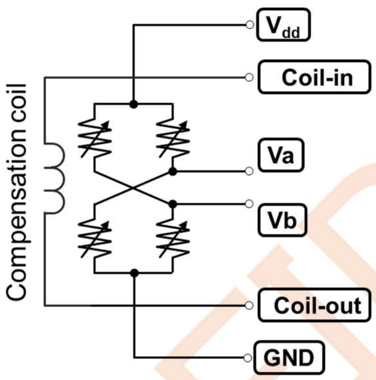


Fig. 3: Compensation coil for a closed loop current

1-3. Detectable measurement range of ac magnetic field and dc environment field

The Nivio xMR sensor is operational under geomagnetism of ±60 µT or below dc field range by using the recommended circuit. In addition, it is able to measure with high sensitivity of pico tesla level which is under 1/1,000,000 of geomagnetic field. The measureable ac magnetic field is achieved to be up to ±250 nT. The magnetic noise density shows 3 pT/√Hz at 1 Hz in the recommend circuit, and it enables to use various usages as super low noise magnetic field sensor.

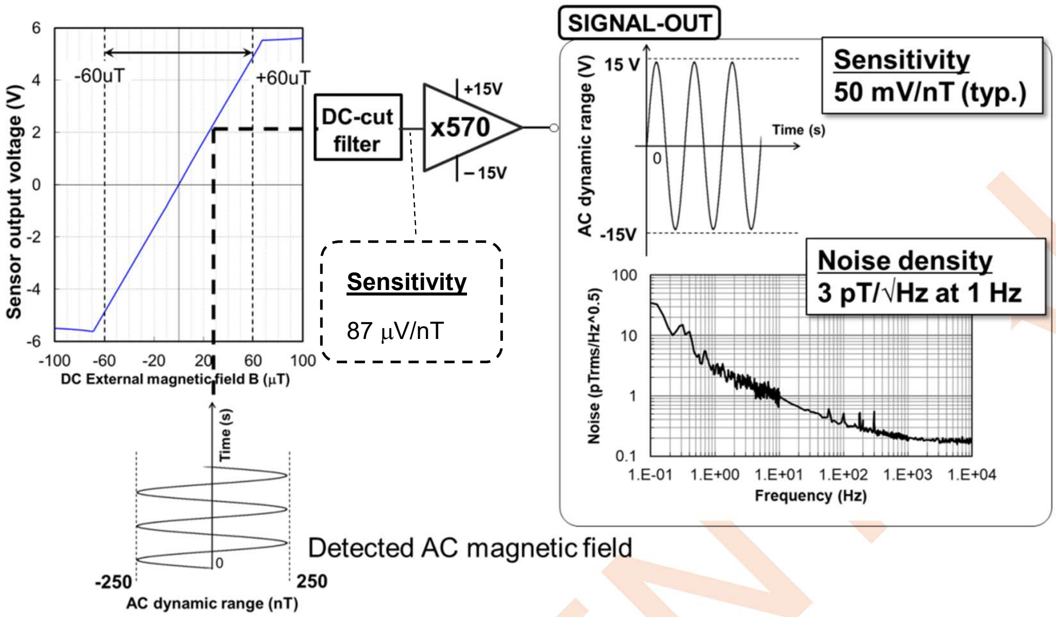


Fig. 4: Schematic diagram about ac magnetic field detection **(under the recommenced circuit)**

2. Nivio xMR sensor structure

2-1. Sensor figure and dimension

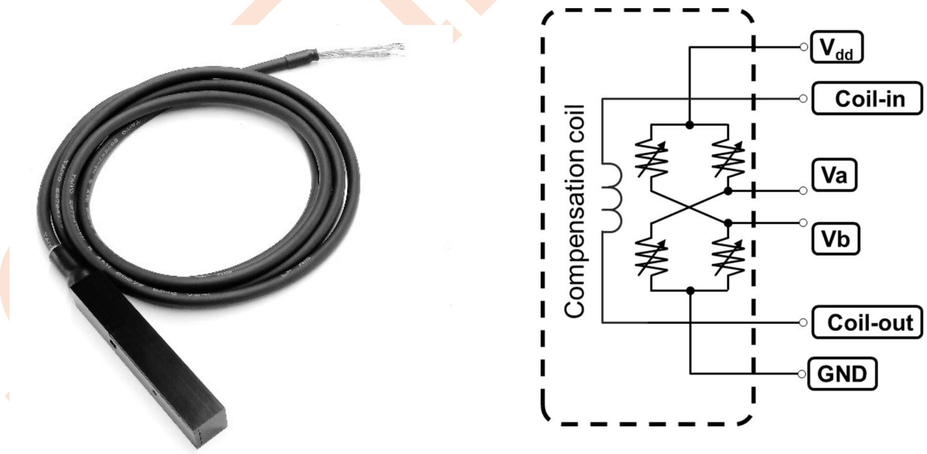


Fig. 5: Sensor image (left) and inside circuit design (right)

Components	Dimension
Sensor with Cable	Head part: 12 x 12 x 74 mm, Cable length: 1.5 m

2-2. Sensor cable drawing table

No.	Name	Dot mark	Connection
1	orange	balck	**Vb**
		red	**Va**
22	grey	black	**Coil-in**
		red	**Coil-out**
33	white	black	**GND**
		red	**Vdd**

2-3. Precaution about electrostatic discharge

Please handle and store the Nivio xMR sensor with appropriate ESD protective measurements. Electrostatic discharge may cause various damages on the devices from slightly lower performance to complete failure. Highly accurate integrated circuit is sensitive to damage and may not adopt the specification of device due to very small change of the parameter. **(JEDEC JS-001 HBM : Class 1A (250 to < 500V))**

3. Electric Property

Symbol	Parameter	Min	Typ.	Max	Unit
R_1	Resistance of Va – Vb	1.2	1.3	1.4	kohm
R_2	Resistance of Coil-in – Coil-out	1.5	2	2.5	ohm
R_3	Resistance of Vdd – GND	1.2	1.3	1.4	kohm
H	Inductance of Coil-in – Coil-out at 1kHz	30	34	38	uH

4. Absolute maximum rating

Symbol	Parameter	Min	Typ.	Max	Unit
Vdd	Positive Power Supply	0	5	6	V
Coil	Current through Coil-in – Coil-out	-60		60	mA
T				75	°C

5. Operating environment range

Symbol	Parameter	Min	Max	Unit
Tope	Operating Temperature Range	0	50	°C
Tstg	Storage Temperature Range	-20	75	°C
Hum	Humidity Operating/Storage	5	80	%RH

Environmental resistance performance is not yet evaluated under this condition.

6. Recommended circuit

6-1. Circuit diagram

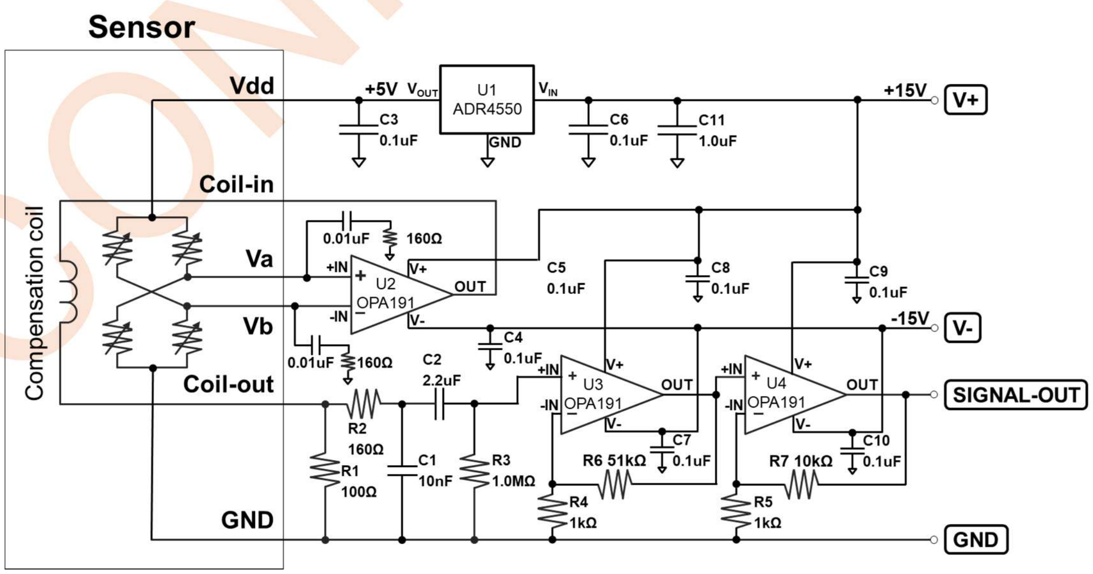


Fig. 6: Recommended circuit design

6-2. Recommended IC

Symbol	Model name	Maker
U1	ADR4550ARZ	ANALOG DEVICES
U2, U3, U4	OPA191ID	TEXAS INSTRUMENTS

7. Recommended circuit operating environment

Symbol	Parameter	Min	Typ	Max	Unit
V+, V-	Supply Voltage	±11	±12	±15	V
Top	Operating Temperature Range		25		°C
Hin	External dc Magnetic Field Density	-60		60	µT

8. Magnetic noise density and signal output attribute at recommended circuit

(Top: 25 ℃, V+, V-: ±15 V)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Noise	Magnetic Noise Density	@ 1 Hz		3		pTrms/√Hz
Sens	Sensitivity			50		mV/nT
H_{RANGE}	Detected AC Field Range		230	250	280	nT
H_{FREQ}	Frequency Range		0.1		10k	Hz

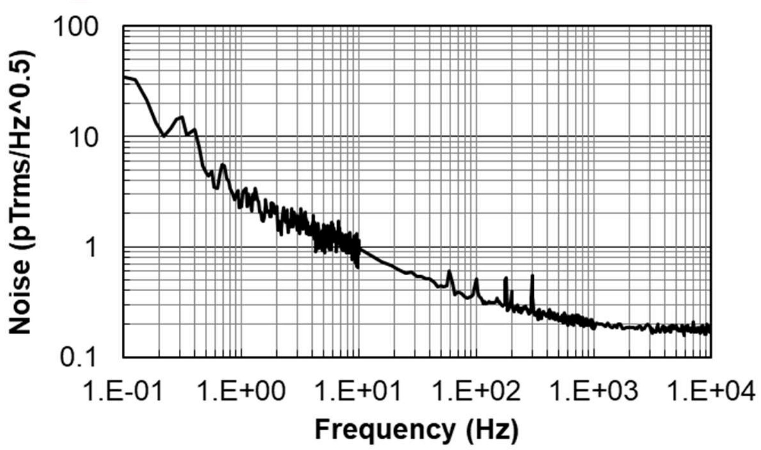


Fig. 7: Magnetic noise density

9. Magnetic field measurement range

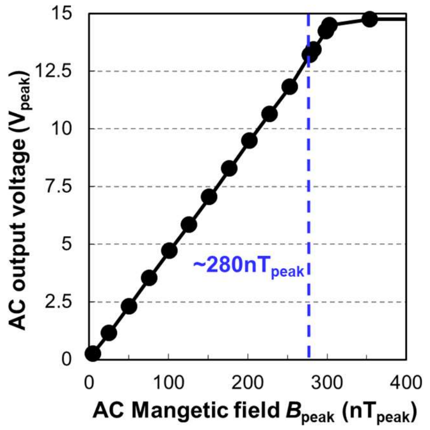


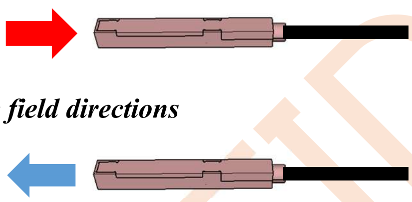
Fig. 8: measurable ac magnetic field range

Operable dc magnetic field range: ±60 μT (Typ.)

Measurable ac magnetic field range: ±250 nT (Typ.)

(Under the recommended circuit condition.)

10. Magnetic field direction and voltage polarity



Positive voltage signal output

Magnetic field directions

Negative voltage signal output