

## Integrated Coreless Current Sensor MRD Series

### 1. General Description

The MRD series is an integrated coreless current sensor which proportionally outputs analog voltage when the current flows through the primary conductor.

It adopts a high-performance TMR sensor to enable high-speed response and high-precision current sensing, and also has a built-in disturbance magnetic field fluctuation suppression function. The product lineup includes bipolar detection model (MRDAB) and unipolar detection model (MRDAC). The MRDAB model and MRDAC model have the same package profile and support 5V and 3V outputs, respectively.

### 2. Features

- Compliant with safety standard of UL62368-1  
(Clearance, Creepage distance  $\geq 8.0\text{mm}$ )
- Current sensing range  
Bipolar detection:  $\pm 25\text{A}_{\text{rms}}$ ,  $\pm 40\text{A}_{\text{rms}}$   
Unipolar detection: 0 to  $+25\text{A}$ , 0 to  $+40\text{A}$
- Total output accuracy  
Bipolar detection: 1.0%F.S. (Ambient temperature  $T_a = -40$  to  $105^\circ\text{C}$ , Max.)  
Unipolar detection: 1.5%F.S. (Ambient temperature  $T_a = -40$  to  $105^\circ\text{C}$ , Max.)
- Supply voltage  
3.3V typ. or 5.0V typ.
- Primary conductor resistance  $0.86\text{m}\Omega$  typ.
- Fast response  $0.5\mu\text{s}$  typ.
- Bandwidth 1MHz typ.
- Band selection (filter) by external capacitor is possible
- Built-in disturbance magnetic field fluctuation suppression function
- Isolation Voltage 4.8kV (AC50Hz, 60s)
- Non-ratiometric output
- Low current consumption

### 3. Applications

- Solar inverters, power conditioners
- Server power supply, telecom power supply
- General-purpose inverter
- EV Charger
- Other applications which are required isolation with small size and suppressing heat generation

**4. Scope**

This document is applied to a current sensor which outputs analog voltage when the current flows through the primary conductor.

**5. Part number**

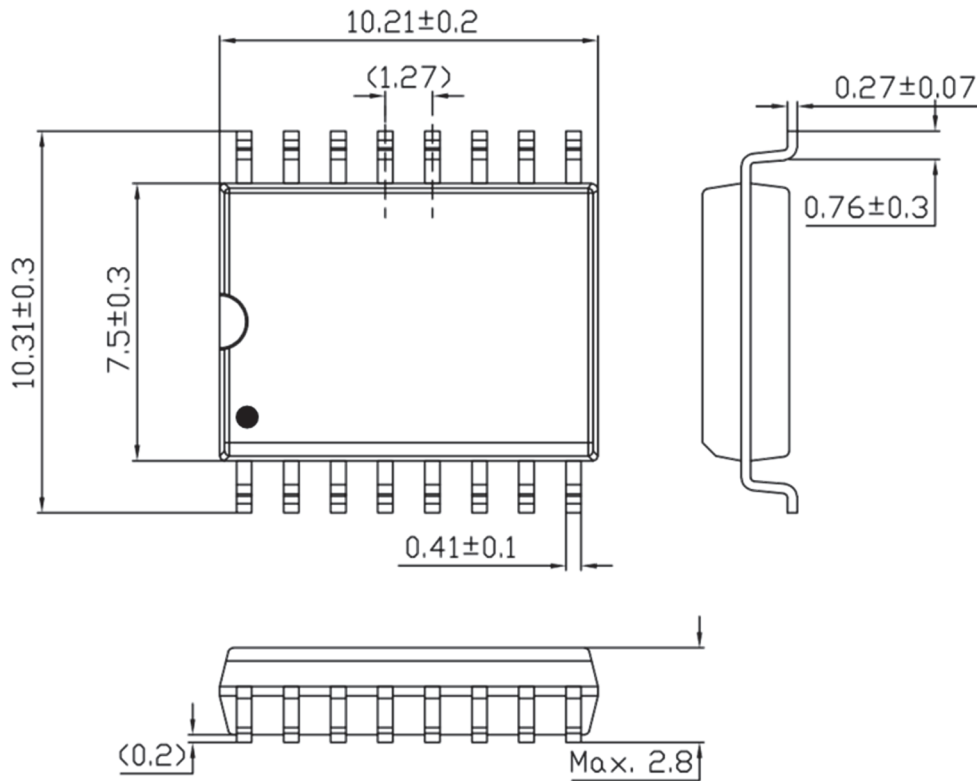
5-1 Part description                      Integrated Coreless Current Sensor

5-2 Part Number List

Part Number	Output	Current Range [A]	Supply Voltage [V]	Total Output Error TA=-40 °C to 105 °C [%F.S.]	Sensitivity [mV/A]
MRDAB3025B	Bipolar	-25 to +25	3.3	1.0	40
MRDAB3040B		-40 to +40			25
MRDAB5025B		-25 to +25	5.0		80
MRDAB5040B		-40 to +40			50
MRDAC3025U	Unipolar	0 to +25	3.3	1.5	80
MRDAC3040U		0 to +40			50
MRDAC5025U		0 to +25	5.0		160
MRDAC5040U		0 to +40			100

**6. Dimensions and Schematics**

6-1 Dimensions



(NOT TO SCALE)

\*Dimensions do not include mold flash, gate burrs, and dambar protrusions.

**Figure 1. Package Outline Drawing (Unit: mm)**

6-2 Packing Specification

•Quantity and Reel

Q'ty per reel : 1000 pcs

Reel Dimension: 13 in X 16mm

•Tape and Pocket Drawing and Dimensions

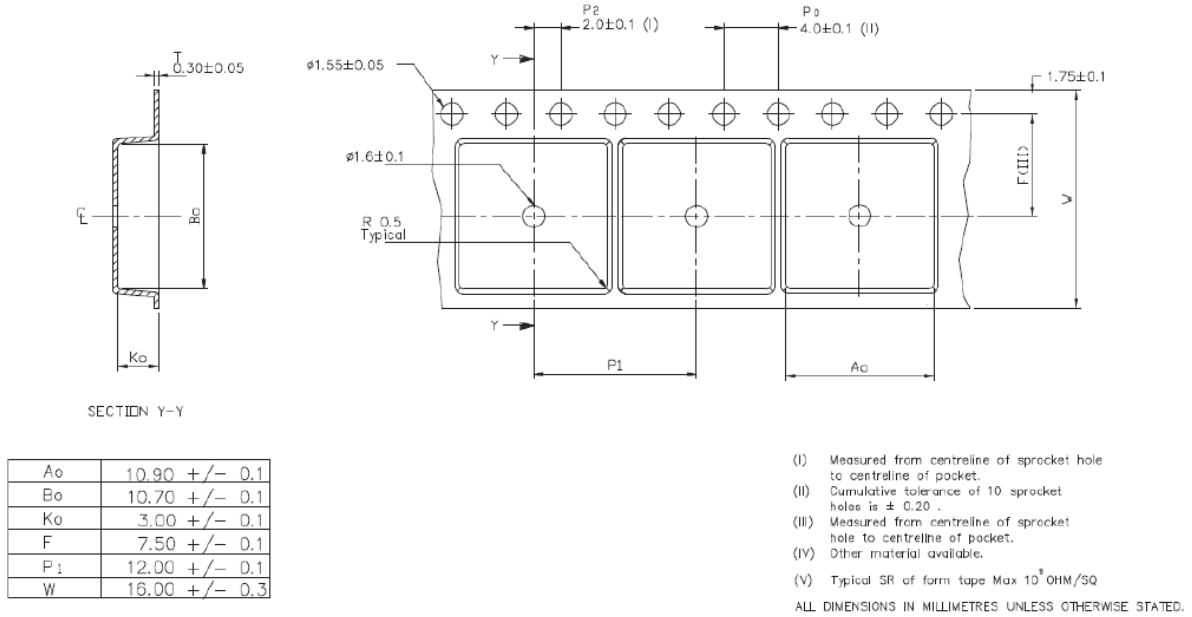


Figure 2. Tape and Pocket Drawing and Dimensions (Unit: mm)

•Tape Pocket Orientation

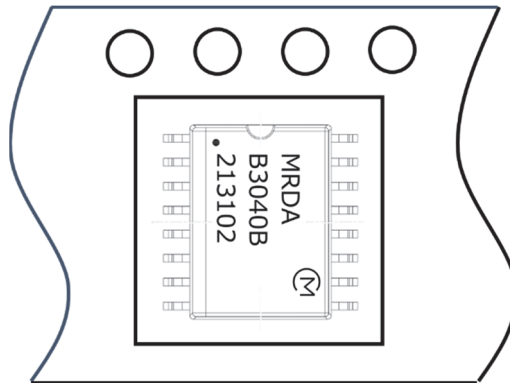
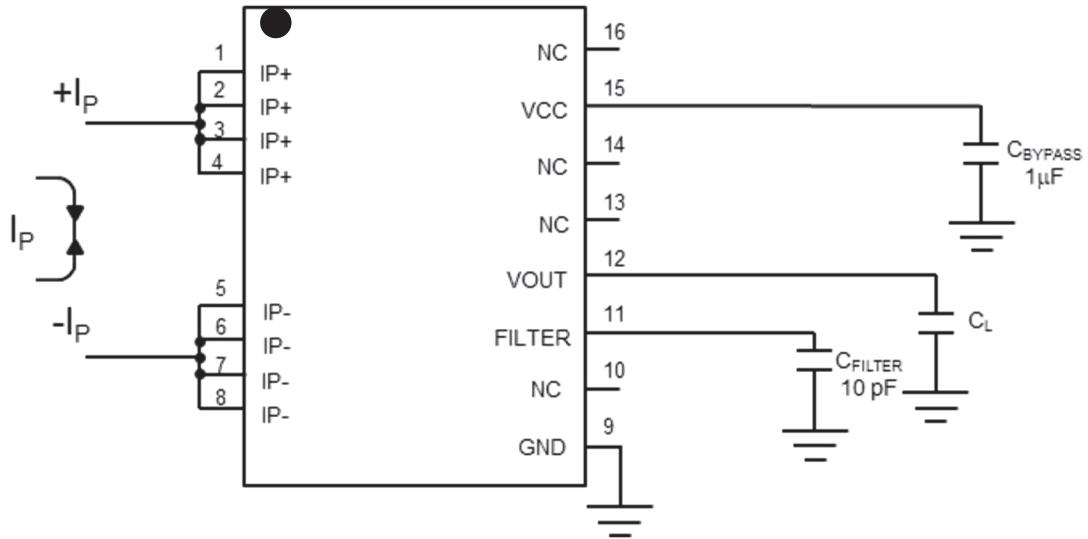


Figure 3. Tape Pocket Orientation

6-3 Typical Application Circuit



\* Place a bypass capacitor of 1 $\mu$ F or more near the VCC and GND terminals.

**Figure 4. Typical Application Circuit**

Terminal List Table

Number	Name	Description
1,2,3,4	IP+	Primary Conductor Pin (+)
5,6,7,8	IP-	Primary Conductor Pin (-)
9	GND	GND
10	NC	No internal connection
11	FILTER	External capacitor terminal for setting bandwidth
12	VOUT	Analog output
13, 14	NC	No internal connection
15	VCC	Supply Voltage
16	NC	No internal connection

6-4 Typical output characteristics

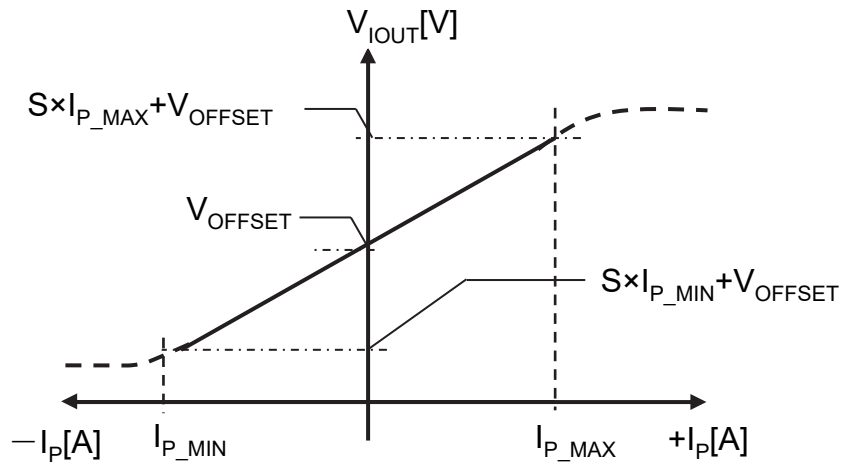


Figure 5-1. Output (Bipolar)

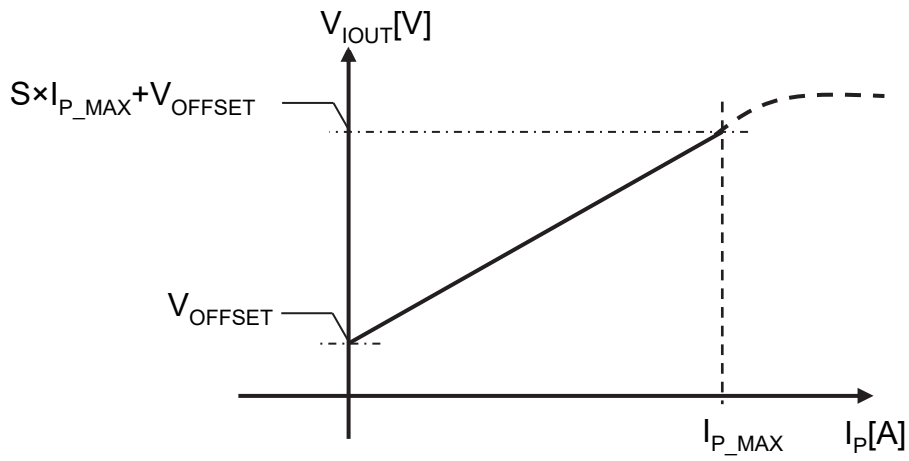


Figure 5-2. Output (Unipolar)

6-5 Reference Pad Dimensions

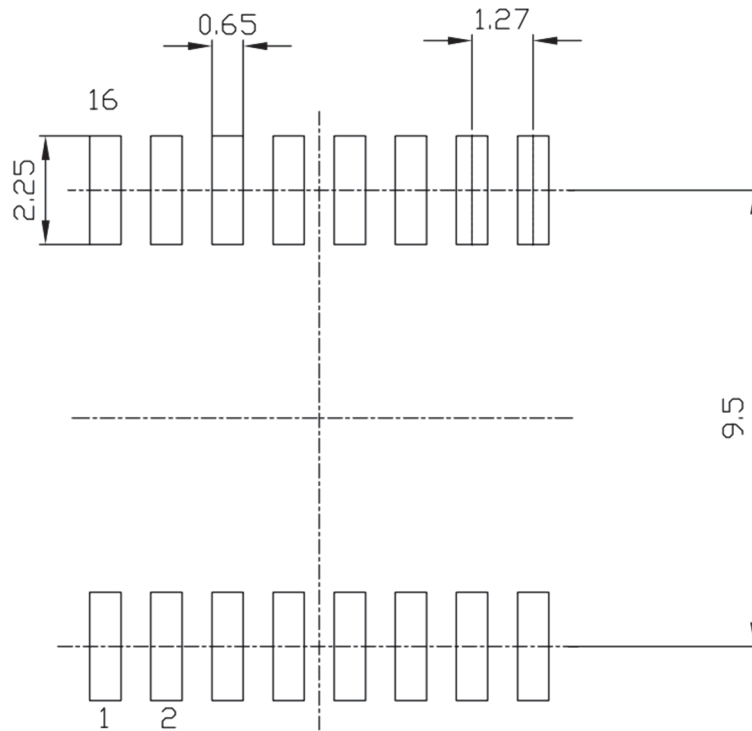


Figure 6-1. Pad Dimensions (Unit:mm)

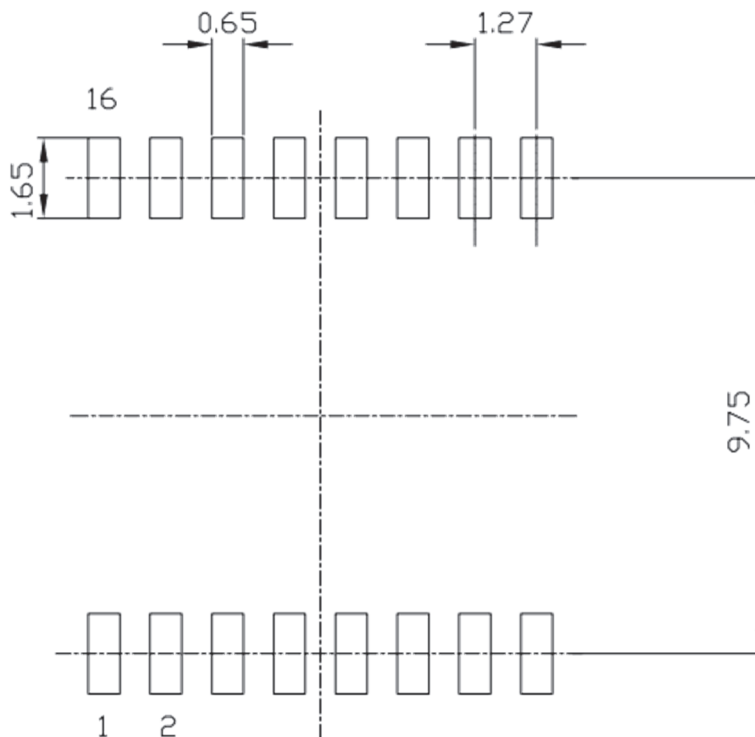


Figure 6-2. High-Isolation Pad Dimensions (Unit:mm)

NOTE1) Please evaluate your soldering paset condition and reflow condition with our product being mounted to your product.

6-6 Functional Block Diagram

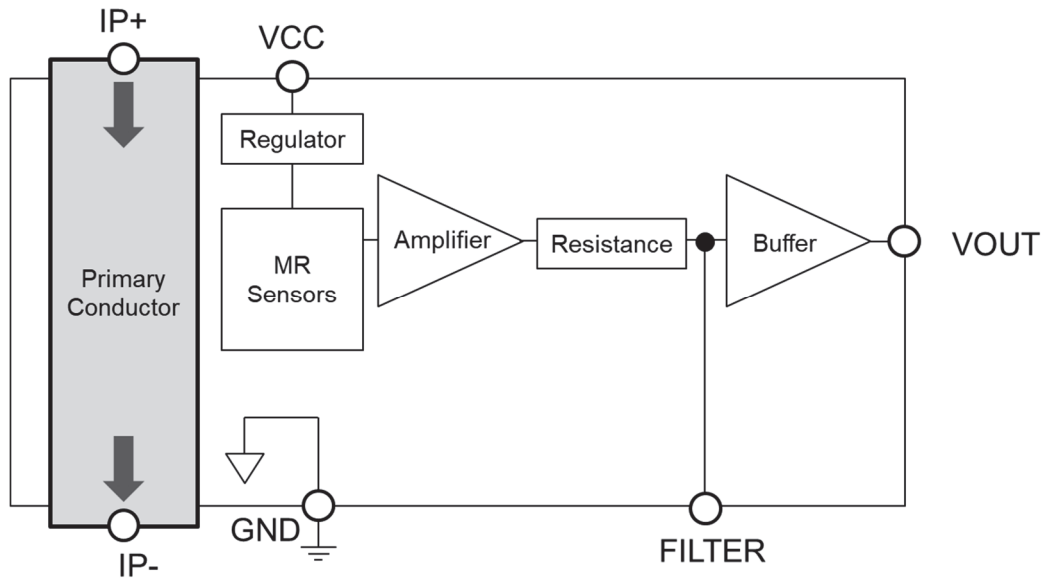


Figure 7. Functional Block Diagram

**7. Specifications**

7-1 Absolute Maximum Rating (Common)

	Characteristic	Symbol	Min.	Max.	Units
1	Supply Voltage	V <sub>CC</sub>	-0.3	6.0	V
2	Output Voltage	V <sub>OUT</sub>	-0.3	V <sub>CC</sub> +0.3	V
3	Junction Temperature	T <sub>J(max)</sub>	-	165	°C
4	Storage Temperature	T <sub>stg</sub>	-40	150	°C
5	Maximum Applied Magnetic Field @T <sub>A</sub> =+25 °C	B <sub>MAX</sub>	-	200	mT

7-2 Isolation Characteristics (Common)

	Characteristic	Symbol	Notes	Min.	Unit
1	Dielectric Strength Test Voltage *1	V <sub>ISO</sub>	Tested for 60 seconds based on UL62368-1.	4800	V <sub>RMS</sub>
2	Clearance	V <sub>CL</sub>	Minimum distance through air from IP leads to signal leads.	8.2	mm
3	Creeping	V <sub>CR</sub>	Minimum distance from package body from IP leads to signal leads.	8.2	mm

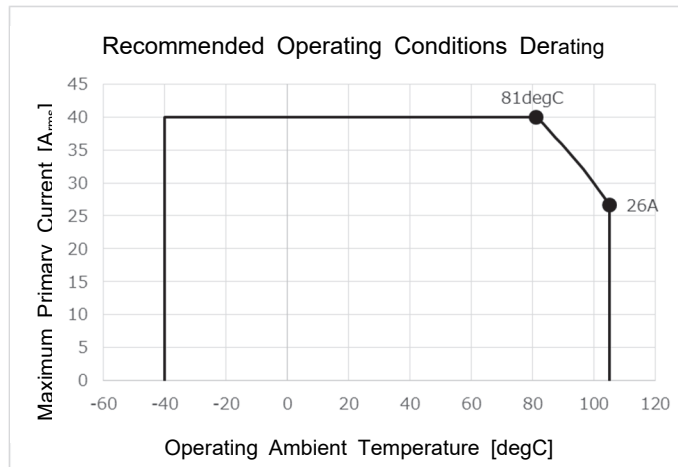
\*1 Sampling inspection by condition 4.8kV<sub>RMS</sub>, 1sec.

7-3 Recommended Operating Conditions (Common)

	Parameter	Symbol	Min.	Max.	Unit
1	Operating Ambient Temperature	T <sub>A</sub>	-40	105	°C
2	Package Temperature *1	T <sub>C</sub>	-40	125	°C
3	Output Load Capacitance	C <sub>L</sub>		100	pF
4	Output Load Resistance	R <sub>LVOUT</sub>	100		kΩ
5	Maximum Primary Current	I <sub>RMS MAX</sub>		40	A <sub>rms</sub>

\*1 Keep the temperature of sensor under 125 °C during current measurement.

\*2 Below is recommended operating conditions derating curve.



**Figure 8. Derating Curve**



## 7-4 Common Electric Characteristics

## 7-4-1 MRDAB3025B, MRDAB3040B, MRDAC3025U, MRDAC3040U

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Supply Voltage *2	$V_{CC}$		2.97	3.30	3.63	V
2	Current Consumption *2	$I_{CC}$	(No Load)	-	4.5	7.5	mA
3	Output Saturation Voltage H *2	$V_{SAT(HIGH)}$		2.65	-	-	V
4	Output Saturation Voltage L *2	$V_{SAT(LOW)}$		-	-	0.65	V
5	Linearity Error *1, *2	$E_N$	$T_A = 25^\circ\text{C}$	-	0.2	-	%F.S.
6	Power-on Time *2	$t_{on}$		-	10	-	$\mu$ s
7	Response Time *2	$t_{RESPONSE}$	$I_P=I_P(\text{max})$ , $T_A=25^\circ\text{C}$ Input current reaches 80% of full scale value Output voltage reaches 80% of full scale value	-	0.5	-	$\mu$ s
8	Internal Bandwidth *2	BW	Small signal -3dB	-	1.0	-	MHz
9	External Capacitor for FILTER Pin *2	$C_{FILTER}$	BW=100kHz BW=250kHz BW=500kHz BW=1MHz		91 39 20 10		pF
10	Shorted Output to Ground Current *2	$I_{SC(GND)}$	$T_A = 25^\circ\text{C}$	-	20	-	mA
11	Shorted Output to VCC Current *2	$I_{SC(VCC)}$	$T_A = 25^\circ\text{C}$	-	22	-	mA
12	Primary Conductor Resistance *2	$R_P$		-	0.86	-	m $\Omega$

\*1 The values can be drifted by long term use or reflow process.

\*2 The parameters are guaranteed in design. No test in mass production.

## 7-4-2 MRDAB5025B, MRDAB5040B, MRDAC5025U, MRDAC5040U

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Supply Voltage *2	$V_{CC}$		4.75	5.00	5.50	V
2	Current Consumption *2	$I_{CC}$	(No Load)	-	5.3	7.5	mA
3	Output Saturation Voltage H *2	$V_{SAT(HIGH)}$		4.5	-	-	V
4	Output Saturation Voltage L *2	$V_{SAT(LOW)}$		-	-	0.5	V
5	Linearity Error *1, *2	$E_N$	$T_A = 25\text{ }^\circ\text{C}$	-	0.2	-	%F.S.
6	Power-on Time *2	$t_{on}$		-	10	-	$\mu$ s
7	Response Time *2	$t_{RESPONSE}$	$I_P=I_P(max)$ , $T_A=25\text{ }^\circ\text{C}$ Input current reaches 80% of full scale value Output voltage reaches 80% of full scale value	-	0.5	-	$\mu$ s
8	Internal Bandwidth *2	BW	Small signal -3dB	-	1.0	-	MHz
9	External Capacitor for FILTER Pin *2	$C_{FILTER}$	BW=100kHz BW=250kHz BW=500kHz BW=1MHz		91 39 20 10		pF
10	Shorted Output to Ground Current *2	$I_{SC(GND)}$	$T_A = 25\text{ }^\circ\text{C}$	-	20	-	mA
11	Shorted Output to VCC Current *2	$I_{SC(VCC)}$	$T_A = 25\text{ }^\circ\text{C}$	-	22	-	mA
12	Primary Conductor Resistance *2	$R_P$		-	0.86	-	m $\Omega$

\*1 The values can be drifted by long term use or reflow process.

\*2 The parameters are guaranteed in design. No test in mass production.

## 7-5 Performance characteristics

## 7-5-1 MRDAB3025B performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25°C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	$I_{PR}$		-25	-	+25	A
2	Sensitivity *1	S		-	40	-	mV/A
3	Offset Voltage *1	$V_{OFFSET}$		-	1.65	-	V
4	Total Output Error *1, *2, *3	$E_{TOT}$	$T_A$ =-40°C to 105°C After offset voltage correction	-	-	1.0	%F.S.

## 7-5-2 MRDAB3040B performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25°C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	$I_{PR}$		-40	-	+40	A
2	Sensitivity *1	S		-	25	-	mV/A
3	Offset Voltage *1	$V_{OFFSET}$		-	1.65	-	V
4	Total Output Error *1, *2 *3	$E_{TOT}$	$T_A$ =-40°C to 105°C After offset voltage correction	-	-	1.0	%F.S.

## 7-5-3 MRDAB5025B performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25°C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	$I_{PR}$		-25	-	+25	A
2	Sensitivity *1	S		-	80	-	mV/A
3	Offset Voltage *1	$V_{OFFSET}$		-	2.5	-	V
4	Total Output Error *1, *2, *3	$E_{TOT}$	$T_A$ =-40°C to 105°C After offset voltage correction	-	-	1.0	%F.S.

## 7-5-4 MRDAB5040B performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25°C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	$I_{PR}$		-40	-	+40	A
2	Sensitivity *1	S		-	50	-	mV/A
3	Offset Voltage *1	$V_{OFFSET}$		-	2.5	-	V
4	Total Output Error *1, *2 *3	$E_{TOT}$	$T_A$ =-40°C to 105°C After offset voltage correction	-	-	1.0	%F.S.

## 7-5-5 MRDAC3025U performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	I <sub>PR</sub>		0	-	+25	A
2	Sensitivity *1	S		-	80	-	mV/A
3	Offset Voltage *1	V <sub>OFFSET</sub>		-	0.65	-	V
4	Total Output Error *1, *2, *3	E <sub>TOT</sub>	$T_A$ =-40 °C to 105 °C After offset voltage correction	-	-	1.5	%F.S.

## 7-5-6 MRDAC3040U performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	I <sub>PR</sub>		0	-	+40	A
2	Sensitivity *1	S		-	50	-	mV/A
3	Offset Voltage *1	V <sub>OFFSET</sub>		-	0.65	-	V
4	Total Output Error *1, *2 *3	E <sub>TOT</sub>	$T_A$ =-40 °C to 105 °C After offset voltage correction	-	-	1.5	%F.S.

## 7-5-7 MRDAC5025U performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	I <sub>PR</sub>		0	-	+25	A
2	Sensitivity *1	S		-	160	-	mV/A
3	Offset Voltage *1	V <sub>OFFSET</sub>		-	0.5	-	V
4	Total Output Error *1, *2, *3	E <sub>TOT</sub>	$T_A$ =-40 °C to 105 °C After offset voltage correction	-	-	1.5	%F.S.

## 7-5-8 MRDAC5040U performance characteristics

Unless otherwise specified:

 $V_{CC}$ =Typical  $V_{CC}$ ,  $C_{BYPASS}$ =1.0 $\mu$ F,  $C_{FILTER}$ =10pF and  $T_A$ =+25 °C

	Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
1	Current Sensing Range	I <sub>PR</sub>		0	-	+40	A
2	Sensitivity *1	S		-	100	-	mV/A
3	Offset Voltage *1	V <sub>OFFSET</sub>		-	0.5	-	V
4	Total Output Error *1, *2 *3	E <sub>TOT</sub>	$T_A$ =-40 °C to 105 °C After offset voltage correction	-	-	1.5	%F.S.

\*1 The values can be drifted by long term use or reflow process.

\*2 The parameters are guaranteed in design. No test in mass production.

\*3 The maximum value is defined as "average value  $\pm 3\sigma$ " of a certain lot.

## 8. Definitions of characteristics

### 8-1 Response Time

The time interval between when input current reached 80% of full scale value and when it reaches 80% of full scale value.

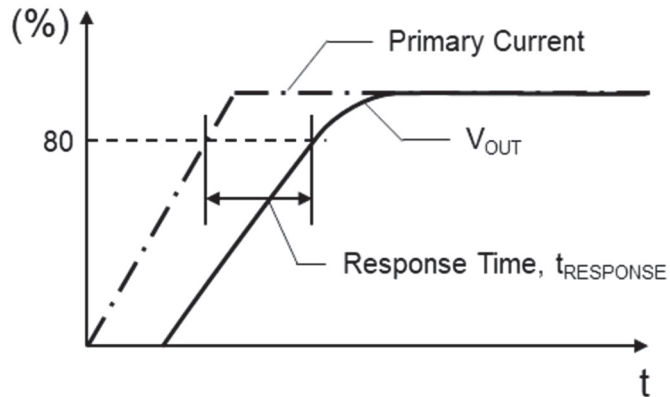


Figure 9. Response Time ( $t_{\text{RESPONSE}}$ )

### 8-2 Bandwidth

The bandwidth is defined by the frequency at which the output voltage reaches -3 dB.

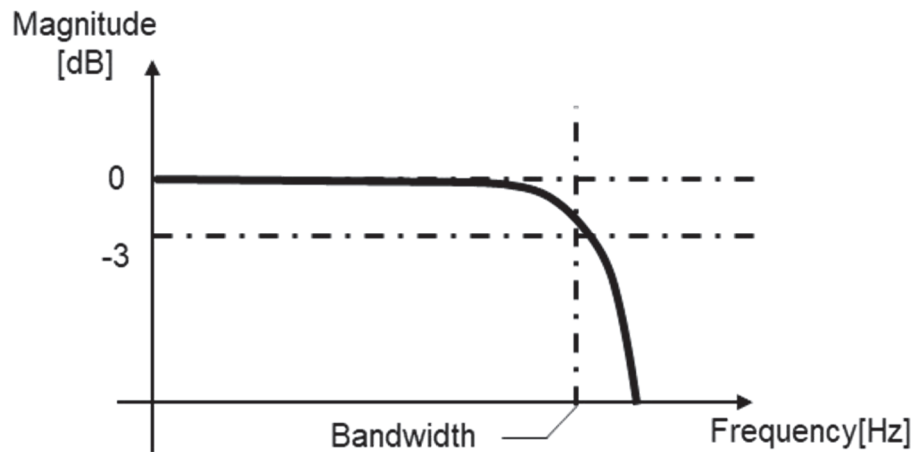


Figure 10. Bandwidth (BW)

### 8-3 Power-on Time

The time it takes for the output voltage to within  $\pm 10\%$  of its steady-state value under an applied current, after the power supply has reached its minimum specified operating voltage ( $V_{CC(\min)}$ ).

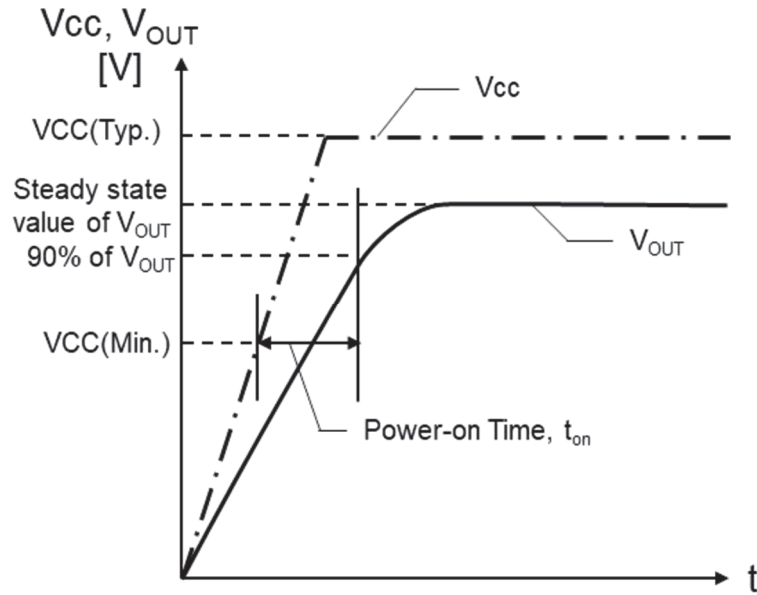


Figure 11. Power-on Time ( $t_{on}$ )

### 8-4 Sensitivity

The change in sensor output to a 1A change through the input current.

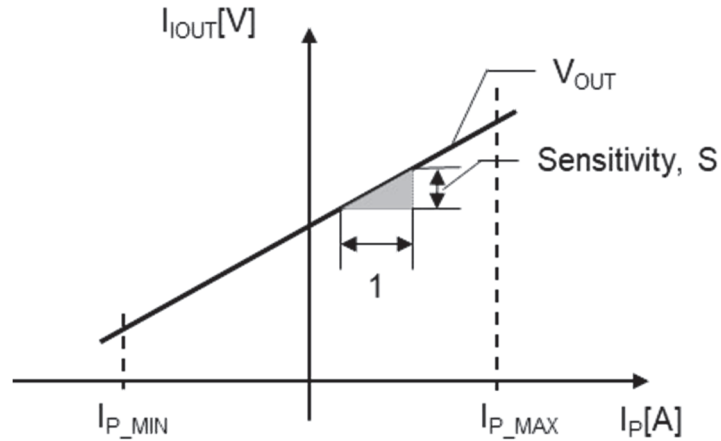
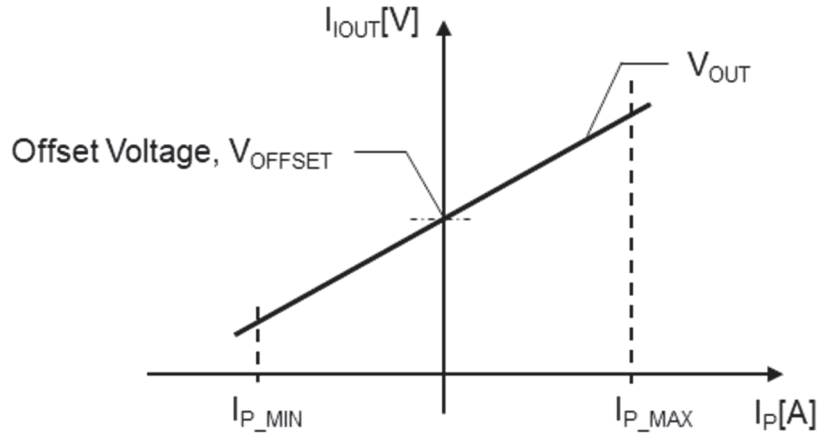


Figure 12. Sensitivity

### 8-5 Offset Voltage

The output voltage when the input current is zero.



**Figure 13. Offset Voltage**

### 8-6 Linearity Error

Linearity( $E_N$ ) is defined as the ratio of the maximum error voltage ( $V_d$ ) to approximate straight line to full scale. The formula is below.

$$E_N = \frac{|V_d|}{V_{FullScale}} \times 100[\%F.S.]$$

$V_d$ :Maximum value of the difference between sensor output( $V_{out}$ ) and approximate linear output( $V_{Line}$ ).

$V_{out}$ :Measured value of sensor output.

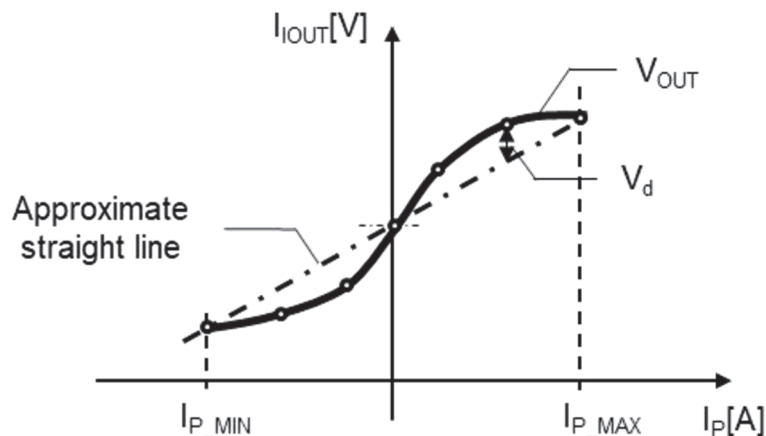
$V_{Line}$ :The formula is below.

$$V_{Line}(I_p) = S_{measure} \times I_p + V_{Off\_measure}[V]$$

$S_{measure}$ :Measured value of sensitivity.

$V_{Off\_measure}$ :Measured value of offset.

$V_{FullScale}$ :Difference between the minimum value of Output Saturation Voltage H and the maximum value of Output Saturation Voltage L.



**Figure 14. Linearity Error**

### 8-7 Total Output Error

Total Output Error( $E_{TOT}$ ) is defined as the ratio of the maximum error of sensor output( $V_E$ ) to ideal straight line to full scale. The formula is below.

$$E_{TOT} = \frac{|V_E|}{V_{FullScale}} \times 100[\%F.S.]$$

$V_E$ : Maximum value of difference between sensor output ( $V_{out}$ ) and ideal output ( $V_{ideal}$ ).

$V_{ideal}$ : The formula is below.

$$V_{ideal} = S_{typ} \times I_p + V_{offtyp}[V]$$

$S_{typ}$ : Type value of sensitivity.

$V_{offtyp}$ : Type value of Offset voltage.

$V_{FullScale}$ : Difference between the minimum value of Output Saturation Voltage H and the maximum value of Output Saturation Voltage L.

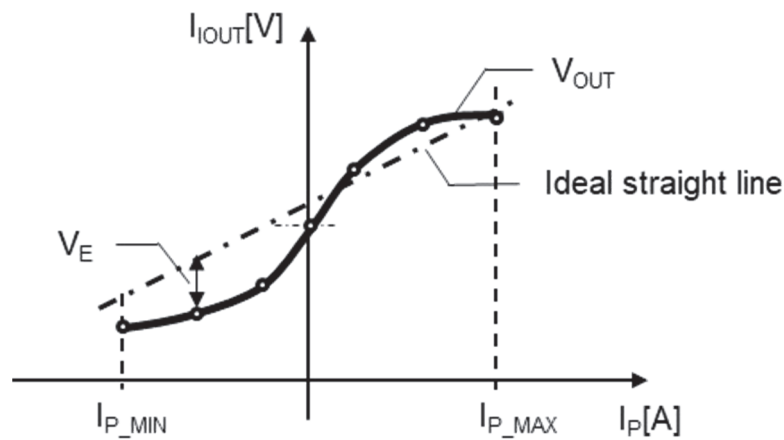


Figure 15. Total Output Error



## 9. Reliability Tests

Test parameters and conditions of reliability tests

No	Test Parameter	Test Conditions (Reference)	n	Test Time
1	High Temperature Bias Test	T <sub>a</sub> =125 °C, continuous operation (JESD22-A108)	22	1000h
2	Temperature Humidity Bias Test	T <sub>a</sub> =85 °C, 85%RH, continuous operation (JESD22-A101)	22	1000h
3	Temperature Cycling Test	-40 °C to +125 °C 30min. 30min. Tested in vapor phase (JESD22-A104)	22	1000 Cycles
4	High Magnetic Field Test	H <sub>ext</sub> =200mT	22	10s

Tested samples are pretreated as below before each reliability test:  
Desiccation: 120 °C /24h→Moisture Absorption: 30 °C /60%RH/192h  
→Reflow: 3 times (JEDEC Level3)

Criteria:

The variation from pretreatment to each reliability test is within the following range.

- MRDAB3025B, MRDAB3040B, MRDAB5025B, MRDAB5040B  
Sensitivity (T<sub>a</sub>=25 °C) : Within±1.5%  
Offset Voltage (T<sub>a</sub>=25 °C) : Within±0.75%F.S.  
Total Output Error : Within±1.0%F.S.
- MRDAC3025U, MRDAC3040U, MRDAC5025U, MRDAC5040U  
Sensitivity (T<sub>a</sub>=25 °C) : Within±1.5%  
Offset Voltage (T<sub>a</sub>=25 °C) : Within±0.75%F.S.  
Total Output Error : Within±1.6%F.S.

## 10. Caution

### 10-1 Limitation of applications

Please avoid using this product for the applications listed below which require especially high reliability in order to prevent defects that might directly cause damage to the third party's life, body, or property.

When this product is used for the applications listed below, we shall not be liable for any claims on the product.

- ① Aircraft equipment
- ② Aerospace equipment
- ③ Undersea equipment
- ④ Generating plant equipment
- ⑤ Medical equipment
- ⑥ Transportation equipment (vehicles, trains, ships, etc.)
- ⑦ Traffic signal equipment
- ⑧ Disaster prevention/ crime prevention equipment
- ⑨ Data processing equipment
- ⑩ Application of similar complexity and/or reliability requirements to the applications listed above.

### 10-2 Fail-safe

Be sure to provide appropriate fail-safe function on your product to prevent a second damage that may be caused by the abnormal function or the failure of our product.

## 11. Caution for use

### 11-1 Handling

This product may be degraded by electrostatic discharge. It is necessary to take anti-static precautions when handling.

### 11-2 Design

- Sensor miss-operation or non-operation may occur due to the influence of the magnetic noise from surrounding devices such as motor. Please make sure there is no influence of the magnetic noise in designing process.
- If the voltage of the primary terminal fluctuates greatly, please evaluate this product before using.
- Please be careful about a magnetic body (Iron, Nickel, etc.) and a magnetic noise immunity that may affect the sensor.
- Please do not supply inverse voltage or excess voltage to this product including impulse noise. If applied, this product may be damaged and electrically destroyed.
- Please use decoupling capacitor of sufficient capacity to prevent excess voltage from being applied to Vcc-GND.
- Please design your product not to be affected by stress of the resin due to heat shrink.
- If the voltage of the primary terminal fluctuates greatly, please evaluate this product before using. When the noise of the primary terminal voltage affects the signal terminal, this sensor output may be abnormal.

#### 11-3 Storage condition

- The Recommended storage conditions in the unopened state are as follows.

Temperature : +5 to +30°C  
Humidity : 70% (RH)% and lower

\*Storage period is one year after delivery.

- Allowable storage time of the product is one year from the date of delivery. Please take account of the storage conditions listed above. Please also use the product as soon as possible after opening the product packing to avoid the deterioration of solderability.
- Please avoid the water, chemical solvent, or oil.
- Please avoid the corrosive gas (Cl<sub>2</sub> H<sub>2</sub>S, NH<sub>3</sub> NO<sub>2</sub>, NO<sub>3</sub> etc.)
- Please avoid the strong vibration or shock.

#### 11-4 Mounting

- Please mount this product under standard reflow condition. Otherwise this product may be damaged.
- Please do not apply excessive load to the terminals. Also, please do not bend the terminals.
- Please do not apply excessive bending stress to the product by bending the PCB or by similar handling as it may change the sensor electric characteristics.

#### 12. Note

- Make sure that your product has been evaluated in view of your specifications with our product being mounted to your product.
- Not to use our product deviating from the agreed specification.
- The current sensor described in this document is under development, our company cannot guarantee the outline drawing or specifications until mass production starts. Also, designs and specs may change without guidance.