The MCS series of current sensors provides a small and cost-effective solution for measuring AC and DC currents in industrial and automotive applications, and it offers a variety of output modes.

Features and Benefits

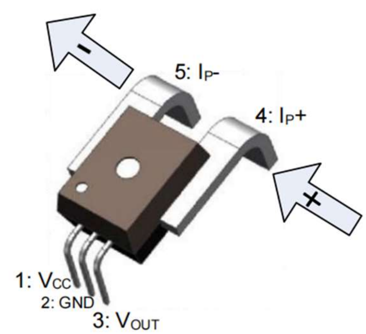
- Open-loop current sensor based on Hall effect induction
- Single 5V power supply
- Analog voltage output
- Supports unidirectional or bidirectional currents
- ±50A to ±200A current range
- Sensor operating temperature range: -40℃ to +125℃
  (150A for -40 °C to +105°C；200A for -40 °C to +85°C)
- Optional 0.5V or 2.5V zero-current output voltage
- Optional ratiometric output (proportional to the supply voltage) or non-ratiometric output
- Good accuracy, linearity and temperature drift
- Low series-resistance limits internal power consumption and heating

Application

- EV/HEV motor controllers
- AC Inverters
- DC/DC converters

Pin definition:

Pin	Name	Description
1	V_{CC}	Sensor power supply
2	GND	GND
3	V_{OUT}	Sensor analog output
4	I_{P+}	Current inflow+
5	I_{P-}	Current outflow-

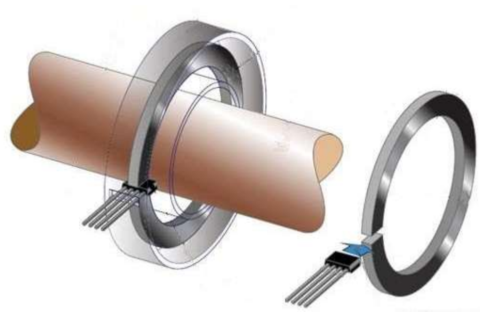


Working Principle:

The open-loop current sensor makes use of Ampere's law (the magnetic field generated around a direct wire is proportional to the current in the wire) and the characteristics of Hall device to detect the magnitude of the magnetic field intensity. The magnetic field is contained and concentrated around the magnetic core. Within the saturation range of the core material,
I_P the proportional relationship between B and I is

$B(I_P) = K * I_P$, where:

- I_P is the primary current to be measured
- K is a constant depending on the geometry of the system



The Hall effect voltage can be expressed as

$V_H=(R_H/D) * I_H * K * I_P$, where:

- RH is the Hall coefficient (depending on the semiconductor properties)
- D is the depth of the Hall sensor
- I_H is the bias current through the Hall sensor
- B is the magnetic field

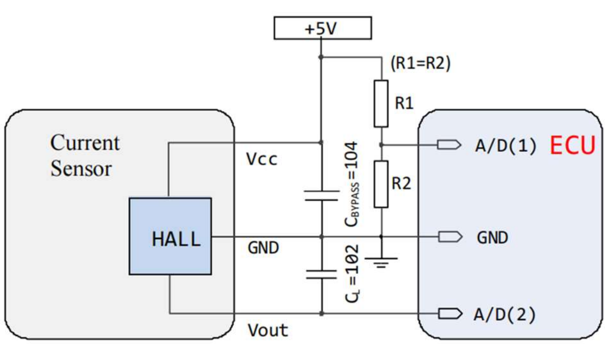
Combining the two equations gives:

$V_H=(R_H/d) * I_H * K * I_P$, or $V_H=K_1 * I_P$, where

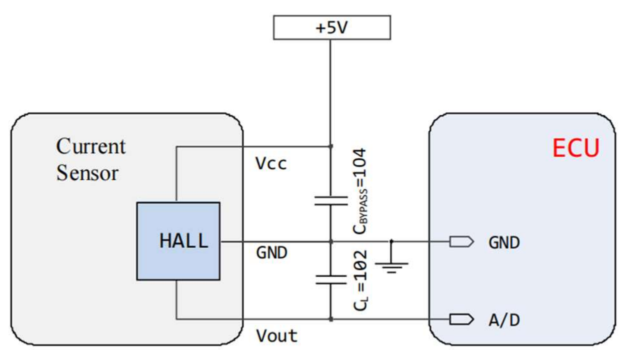
- K_1 is a constant including the sensor materials and geometries

By amplifying and calibrating V_H, we measure the voltage which is proportional to the primary current.

Typical Application circuit:



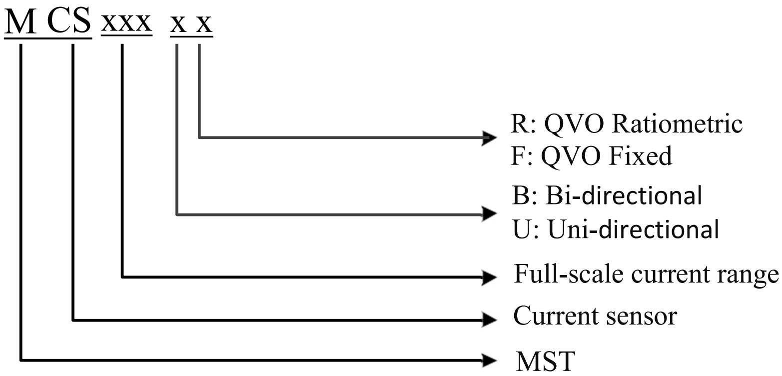
-xR version: $V_{QVO}=V_{CC}/2$ (ratiometric for double-ended ADC)



-xF version: V_{QVO}= 2.5V (fixed gain for single-ended ADC)

**The VCC capacitor C_{BYPASS} should be as close as possible to the module's supply pins*

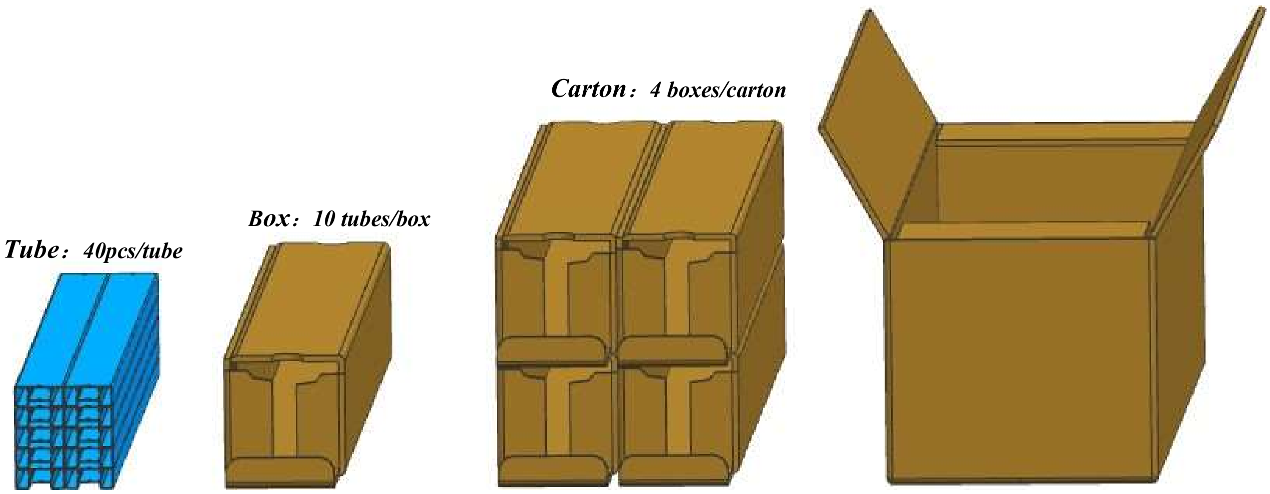
Ordering Information



Model	Zero-Current $V_{OUT(Q)}$ (V)	Primary Current Range I_P (A)	Sensitivity (Typical) (mV/A)	Minimum Packing Quantity (PCS)	Minimum Order Quantity (PCS)
MCS050BR	V_{CC}/ 2	±50	40	40	400
MCS050BF	2.50				
MCS050UR	V_{CC}/ 10	50	80	40	400
MCS050UF	0.50				
MCS100BR	V_{CC}/ 2	±100	20	40	400
MCS100BF	2.50				
MCS100UR	V_{CC}/ 10	100	40	40	400
MCS100UF	0.50				
MCS150BR	V_{CC}/ 2	±150	13.33	40	400
MCS150BF	2.50				
MCS150UR	V_{CC}/ 10	150	26.67	40	400
MCS150UF	0.50				
MCS200BR	V_{CC}/ 2	±200	10	40	400
MCS200BF	2.50				
MCS200UR	V_{CC}/ 10	200	20	40	400
MCS200UF	0.50				

** For current beyond the standard current specification please contact the factory*

Packing information:



Absolute Maximum Ratings

Characteristic	Symbol	Rating	Unit
Supply voltage	V_{CC}	-0.3 to 6.5	V
Supply current	I_{CC}	18	mA
Output voltage	V_{OUT}	0.15 to V_{CC}-0.15	V
Output current	I_{OUT}	±40	mA
Working temperature	T_A	-40 to 150	°C
Maximum junction temperature	T_J	165	°C
Storage temperature	T_S	-55 to 165	°C

Electrical Specifications

Vcc=5.0V (unless otherwise stated), T_A within the specified temperature range.

<table>
<tr><th>Parameter</th><th>Symbol</th><th colspan="2">Condition</th><th>Min</th><th>Typ.</th><th>Max</th><th>Unit</th></tr>
<tr><td>Supply voltage</td><td>V_{CC}</td><td colspan="2"></td><td>4.5</td><td>5</td><td>5.5</td><td>V</td></tr>
<tr><td>Supply current</td><td>I_{CC}</td><td colspan="2">R_L >=10 kΩ</td><td></td><td>13</td><td>18</td><td>mA</td></tr>
<tr><td>Power-on delay</td><td>T_{PO}</td><td colspan="2">T_A= 25°C</td><td></td><td>80</td><td></td><td>µs</td></tr>
<tr><td>QVO Ratiometry Following Vcc (-R)</td><td>E_{RATIO}</td><td colspan="2"></td><td>-0.3</td><td></td><td>0.3</td><td>%</td></tr>
<tr><td rowspan="4">Zero current output</td><td rowspan="4">V_{QVO}</td><td>MCSxxxBR</td><td rowspan="4">I_P = 0, T_A = 25°C</td><td colspan="3">V_{CC}/2</td><td rowspan="4">V</td></tr>
<tr><td>MCSxxxBF</td><td colspan="3">2.50</td></tr>
<tr><td>MCSxxxUR</td><td colspan="3">V_{CC}/10</td></tr>
<tr><td>MCSxxxUF</td><td colspan="3">0.50</td></tr>
<tr><td rowspan="4">Output voltage range</td><td rowspan="4">V_{OUT}-V_{QVO}</td><td>MCSxxxBR</td><td rowspan="2">I = +/- I_P</td><td colspan="3" rowspan="2">±2</td><td rowspan="4">V</td></tr>
<tr><td>MCSxxxBF</td></tr>
<tr><td>MCSxxxUR</td><td rowspan="2">I = 0, I_P</td><td colspan="3" rowspan="2">4</td></tr>
<tr><td>MCSxxxUF</td></tr>
<tr><td>Load resistance</td><td>R_L</td><td colspan="2">V_{OUT} to V_{CC} or GND</td><td>2</td><td></td><td></td><td>KΩ</td></tr>
<tr><td>Load capacitance</td><td>C_L</td><td colspan="2">V_{OUT} TO GND</td><td>6</td><td></td><td>100</td><td>nF</td></tr>
<tr><td>Response time</td><td>$t_{RESPONSE}$</td><td colspan="2">T_A= 25°C, C_L=1nF, I_P step=50% of $I_{P+;}$ to 90% of output voltage</td><td></td><td>3</td><td></td><td>µs</td></tr>
<tr><td>Bandwidth</td><td>BW</td><td colspan="2">Small-signal–3dB, C_L=1nF, T_A=25°C</td><td>120</td><td>170</td><td></td><td>KHz</td></tr>
<tr><td>Output driver impedance</td><td>R_{OUT}</td><td colspan="2">T_A = 25°C</td><td>–</td><td>3</td><td>–</td><td>Ω</td></tr>
</table>

MCS050B Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		-50		50	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		40		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 50A		125	250	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.3	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS050U Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		0		50	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		80		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 50A		80	150	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.15	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS100B Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		-100		100	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		20		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 100A		200	300	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.5	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS100U Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		0		100	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		40		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 100A		100	150	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.250	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS150B Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		-150		150	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		13.33		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 150A		300	400	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.750	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS150U Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		0		150	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		26.67		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 150A		180	320	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.450	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

MCS200B Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

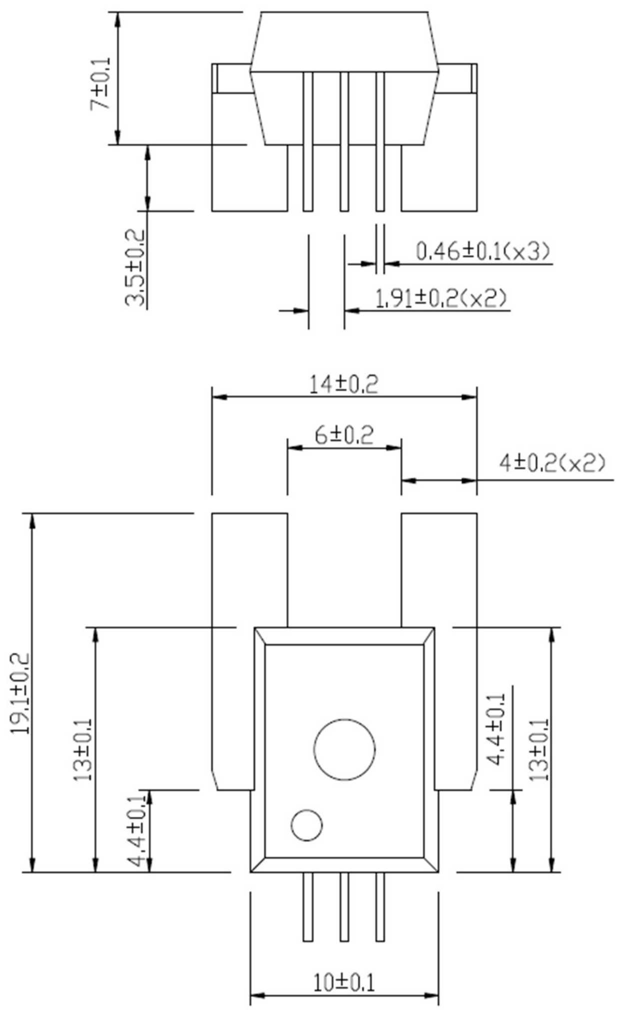
Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		-200		200	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		10		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 200A		400	500	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			1.0	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

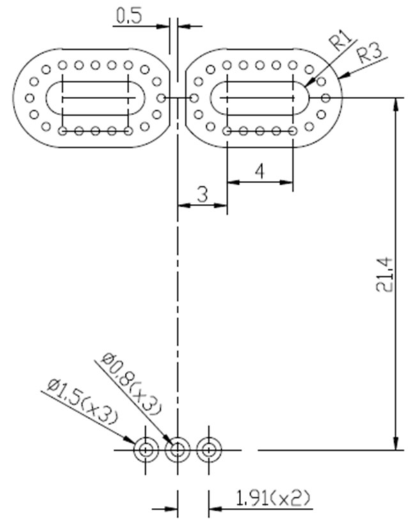
MCS200U Version Performance Parameters

VCC=5.0V (unless otherwise stated), T_A=-40°C ~125°C

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal parameters						
Primary current measurement range	I_P		0		200	A
Sensor sensitivity	$SENS_{TA}$	@V_{CC}=5.0V		20		mV/A
Accuracy parameters						
Sensitivity error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero current offset voltage	V_{OE}	I_P=0A, T_A=25°C	-4	±3	4	mV
		I_P=0A, T_A=-40°C ~125°C	-20	±8	20	mV
Magnetic Hysteresis	I_{OM}	I_P=0A, T_A=25°C, after excursion of 200A		200	250	mA
Zero current offset error	I_{OFFSET}	T_A=25°C			0.5	A
Linearity error	E_{LIN}	Over measurement range	-1	0.5	1	%
Total output error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=–40°C~25°C	-2		2	%

Package Drawing





For reference only) Land Pattern

Definition of performance parameters (1)

- **Zero current offset voltage (V_{QVO}):** sensor output voltage in the state of zero primary current. There are options for fixed or ratiometric V_{QVO}:
  -XR: V_{QVO} follows the supply voltage V_{CC} with a constant ratio; $V_{QVO}=V_{CC}/2$ or $V_{QVO}= V_{CC}/10$
  -XF: V_{QVO} is independent of the supply voltage within the V_{CC} operating range; V_{QVO}= 2.5V, or V_{QVO}=0.5 V

- **Sensor Sensitivity (Sens):** Sensitivity is the slope of the straight-line output voltage**:**

  $$V_{OUT}=V_{QVO}+Sens*I_P$$

  It is measured as the change in output voltage divided by the change in current, and the typical Sensitivity is defined as follows:

  $$Sens = 4V/(I_{P\_MAX} - I_{P\_MIN})$$

- **Electrical Offset Voltage (V_{OE}):** Hall effect sensors are susceptible to voltage shifts due to stress and temperature. With zero magnetic field, there will be a small difference between the voltage error.

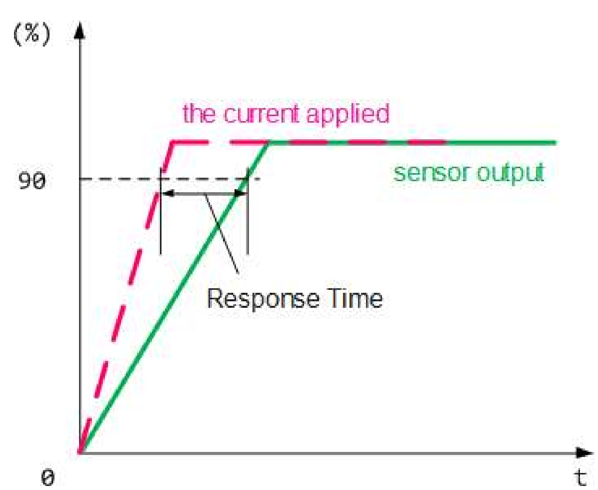
- **Zero Offset Current (I_{OFFSET}):** Due to tolerances, stresses and heat dissipation of internal components, the Electrical Offset Voltage may drift compared to the typical value at room temperature. **I_{OFFSET}** is this drift is expressed in Amperes.

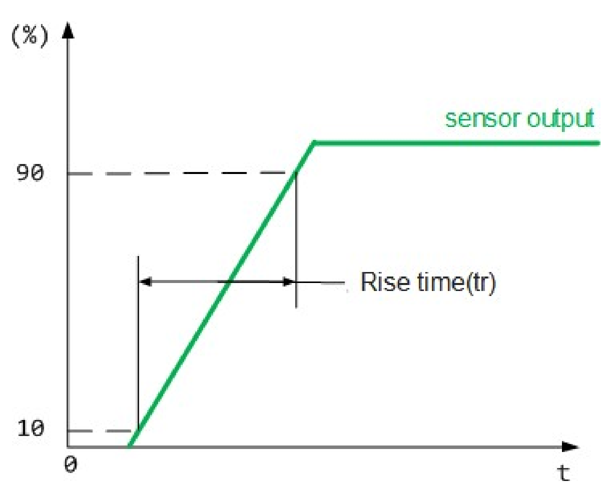
- **Sensitivity with temperature:** Due to the internal temperature compensation factor, the Sensitivity may drift temperature compared to the typical value at room temperature.

- **Magnetic Hysteresis (I_{OM}):** Due to the hysteresis of the magnetic core material of the sensor, when maximum primary current is applied, and then the current returns to zero, the sensor will measure an error current I_{OM}.

- **Response Time:** The time interval between the applied current reaching 90% of its final value, and the corresponding output voltage reaching 90% of the final value.

- **Rise time:** The rise time of the sensor refers to the time interval between 10% of the output of the sensor and the final 90%.





Definition of performance parameters (2)

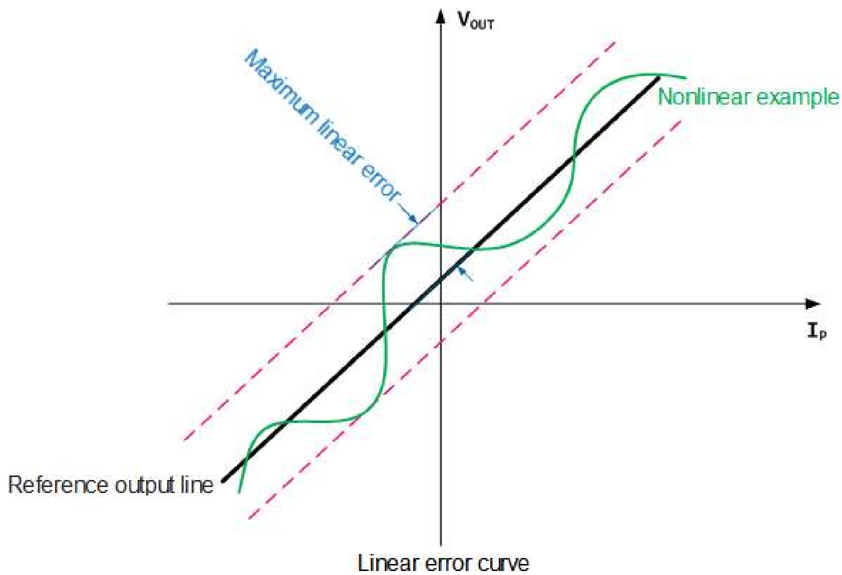
- **QVO Ratiometricity Error (E_{RATIO}):** For –xR versions, the sensor VQVO varies according to the applied supply voltage (4.75 to 5.25V). The Ratiometricity is the deviation between the sensor's zero point output and the theoretical value. It is defined as follows:

$$E_r = \frac{V_{QVO(V_{CC1})}}{V_{QVO(5V)} - V_{CC1}/5} \times 100\%$$

- **Linearity Error ($_{LinERR}$):** The maximum deviation of the output voltage from the ideal straight-line curves:

-BR mode: $V_{OUT}=V_{CC}/2+2\times I_P/I_{P(MAX)}$)

-BF mode: $V_{OUT}=2.5+2\times I_P/I_{P(MAX)}$)



- **Total Output Error (E_{TOT}):** The sensor current measurement value and the actual current (Ip), the formula is defined as the difference between the ideal output voltage and the actual output voltage divided by the ideal sensitivity:

$$E_{TOT(I_P)} = \frac{V_{I_{OUT(I_P)}} - V_{I_{OUT(ideal)(I_P)}}}{Sens_{(ideal)} \times I_P}$$

$$V_{I_{OUT(ideal)(I_P)}} = V_{I_{OUT(Q)}} + (Sens_{(ideal)} \times I_P)$$

At relatively high current, E_{TOT} is mainly due to sensitivity error; At relatively low current, E_{TOT} is mainly due to offset voltage error (V_{OE}). When Ip is near zero, the E_{TOT} calculation has a divide-by-zero component, and is close to infinity.

Design Notes

1. Faulty wiring may cause damage to the sensor. After the sensor is connected to the 5V power supply, the measured current passes through the direction of the sensor arrow, and the corresponding voltage value can be measured at the output end.

2. BR mode: The output voltage V_{OUT} is directly proportional to the supply voltage Vcc,$V_{OUT}=V_{CC}/2+2\times I_P/I_{P(MAX)}$. A change in the supply voltage will cause a change in $V_{OUT.}$
   For example: V_{Cc} range 4.75V to 5.25V-The output range of static output voltage V_{QVO} under the corresponding 0A is 2.375V~2.625V, and the range of full range output($V_{OUT(IPMAX)}$) is 4.275V~4.725V.

3. BF mode: zero output voltage V_{QVO}=2.5V, the gain is fixed at 2V, the output curve is: $V_{OUT}=2.5+2\times I_P/I_{P(MAX)}$; For example: V_{Cc} range 4.75V to 5.25V-The static output voltage V_{QVO} under the corresponding 0A is 2.5V; and the output of full range ($V_{OUT(IPMAX}$) is constant at 4.5V.