Tamura Open Loop Hall Effect Current Sensors

- AC , DC , & Complex Currents
- Galvanic Isolation
- Fast Response
- 50kHz small signal frequency band-width
- Quality & Reliability
- RoHs compliance

[Overview]

Open loop Hall Effect Sensors

The following series of slides presents the relative advantages of the open loop hall effect current sensor as a method for fast, accurate, isolated current measurement of various waveforms over the specified frequency bandwidth.

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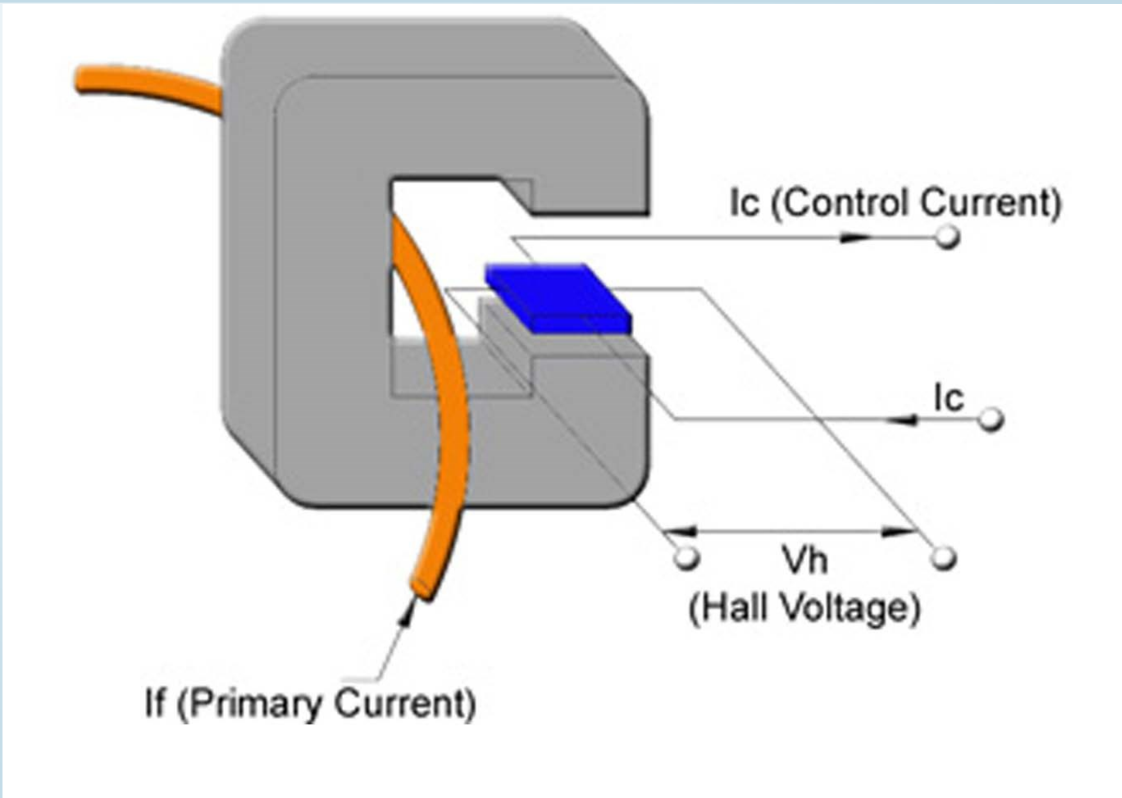

How it works

Open loop Hall Effect Sensors

In an open loop current sensor, the magnetic flux created by the primary current (If) is concentrated in a magnetic circuit and measured using a hall device. The output from the hall device is the signal conditioned to provide an exact (instantaneous) representation of the primary current.

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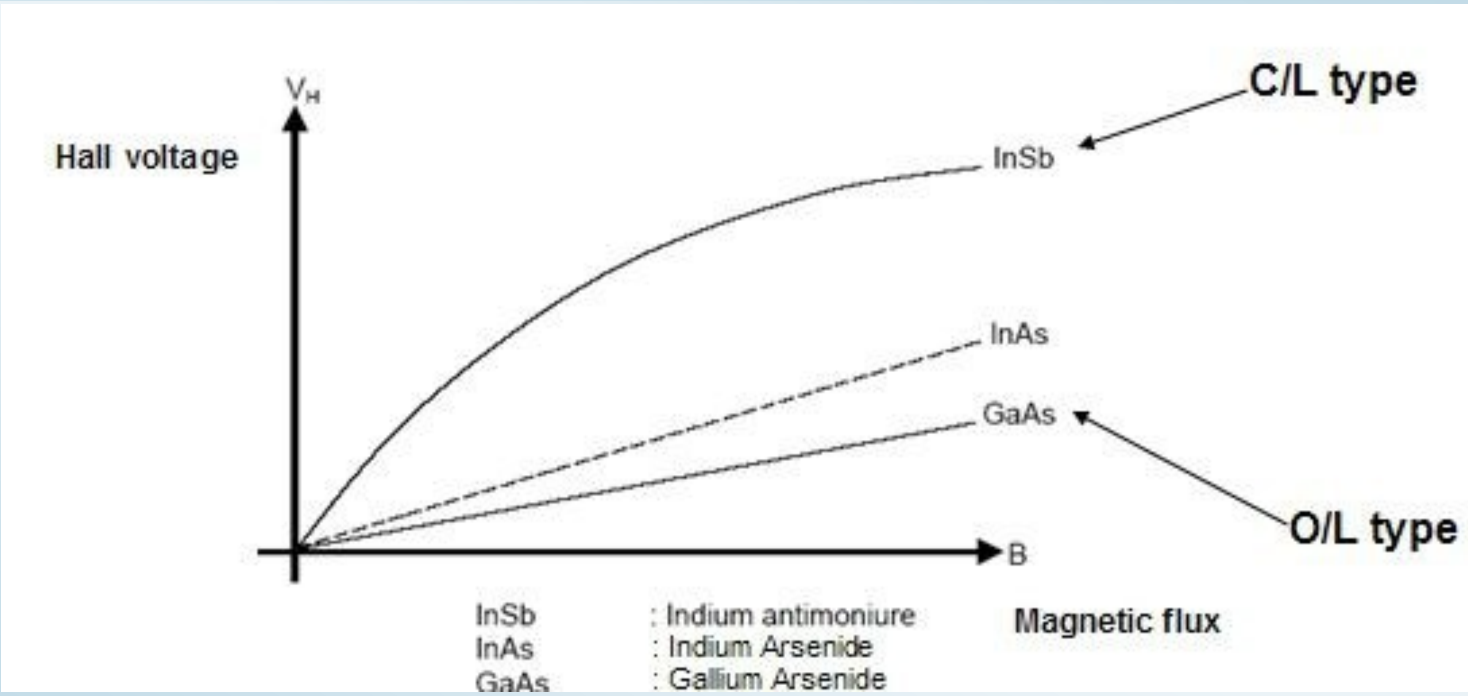
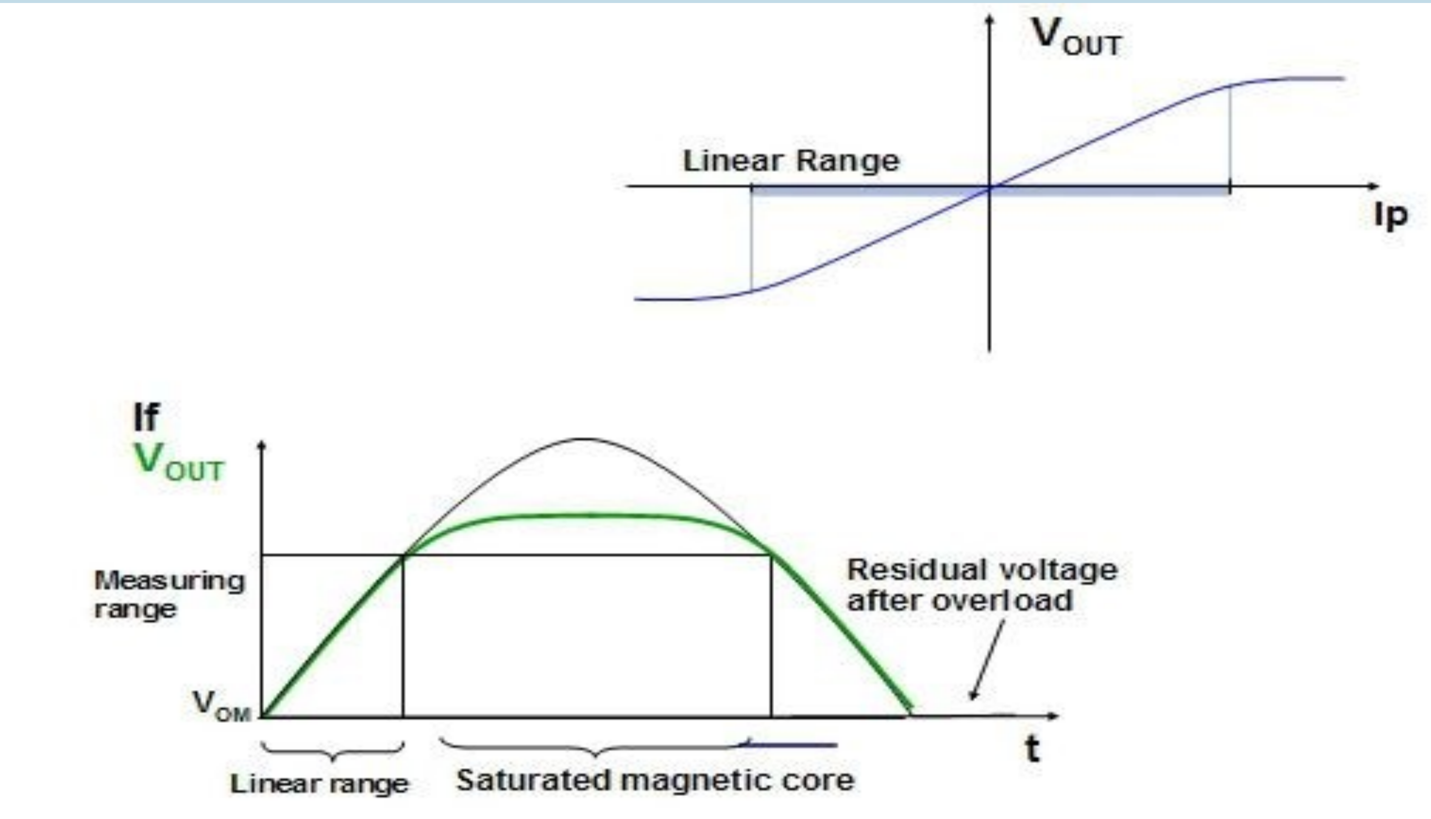


[Linearity]

Open loop Hall Effect Sensors

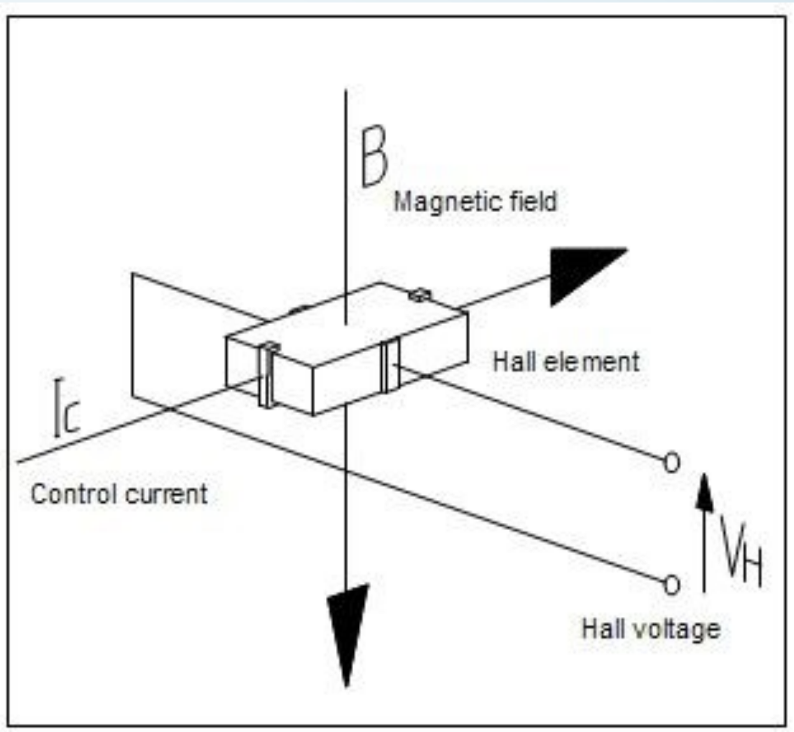
In the case of the open loop current sensor, the hall element chosen for the open loop sensor is typically fabricated from InAs (Indium Arsenide) or GaAs (Gallium Arsenide) for there inherently linear voltage response characteristic to incident magnetic flux.



Saturation Characteristics

Open loop Hall Effect Sensors

The linear range of the open loop current sensor ends when the magnetic core begins to saturate and the output voltage of the current sensor begins to degrade. This is illustrated in the graph on the top. There is no change in the current sensor output voltage once the core or magnetic circuit is saturated, as illustrated by the graph on the bottom of the slide.

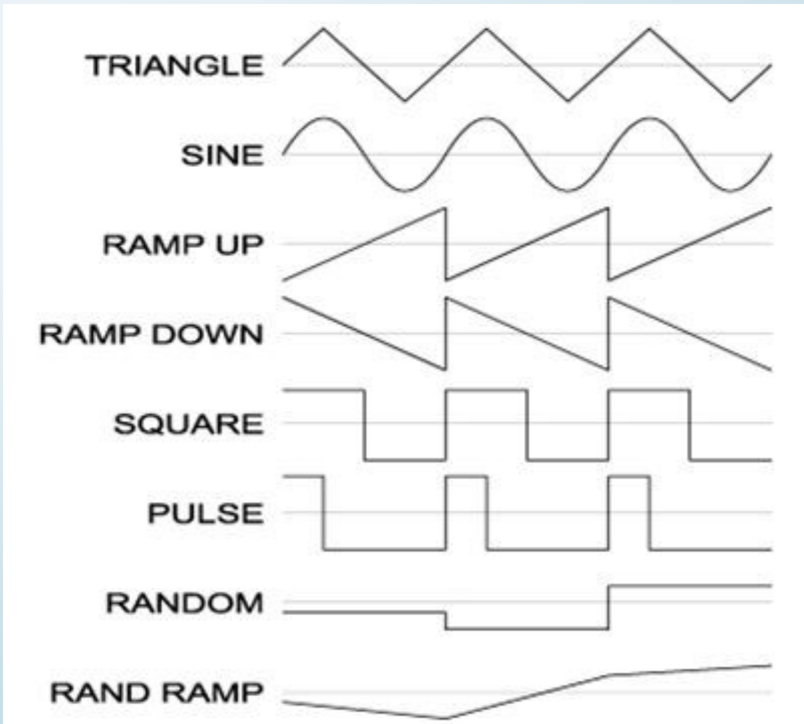


- **Most commonly used magnetic field detector**
- **4 terminal solid state device**
  - basic bridge circuit
- **Used for both AC and DC applications**
- **V_H is proportional to the product of the input current (I) & the magnetic flux density (B)**

[Technical Review]

Open loop Hall Effect Sensors

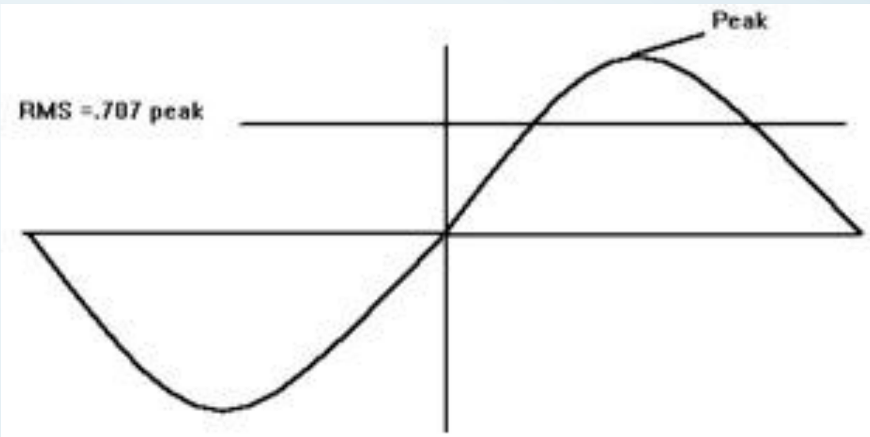
The hall effect element is a four terminal semiconductor device typically fabricated from an InAs (indium arsenide) material selected for the material's sensitivity to magnetic fields. The control current (IC) biases the hall effect element in a quiescent state. The incident magnetic flux creates a charge separation resulting in a potential difference represented by the Hall Voltage, VH. The hall voltage is further signal conditioned to provide an instantaneous voltage representation of the measured primary current.



[Waveforms]

Open loop Hall Effect Sensors

Waveforms come in a varying shapes, magnitudes, and frequencies. Shown here are “ideal” representations of some of the more common waveforms in power electronic systems.



The hall effect current sensor input (Primary) current (If) is typically specified as an RMS or DC value.

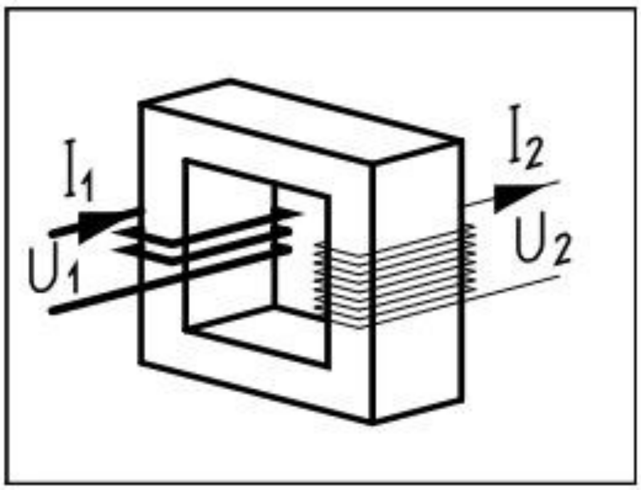
RMS for a sinewave

= I peak / √ 2

For sensors with aperture, the input may be specified in AT. This is the product of conductor current (A) and number of primary turns (T), used to increase the magnitude of current "seen" by the current sensor.

[Input Current] Open loop Hall Effect Sensors

Open loop hall effect current sensor specifications define the input current as the rated as the rated, primary, or nominal current rating of the current sensor as a DC or RMS current. The output voltage of the open loop current sensor is an instantaneous output voltage representation of the primary current whether DC or AC. Therefore the output voltage tracks the input current exactly ; there is no RMS conversion made by the current sensor.



Two electrical circuits are in galvanic isolation if there is no physical contact between their electric conductors; energy exchange occurs between the two circuits by the magnetic field.

In hall effect current sensors, the design and construction allows a guaranteed voltage withstand and insulation resistance; these parameters are confirmed by rigorous testing.

[Galvanic Isolation]

Open loop Hall Effect Sensors

Galvanic Isolation is a major factor in the selection of a open loop hall effect current sensor over the current measurement techniques.

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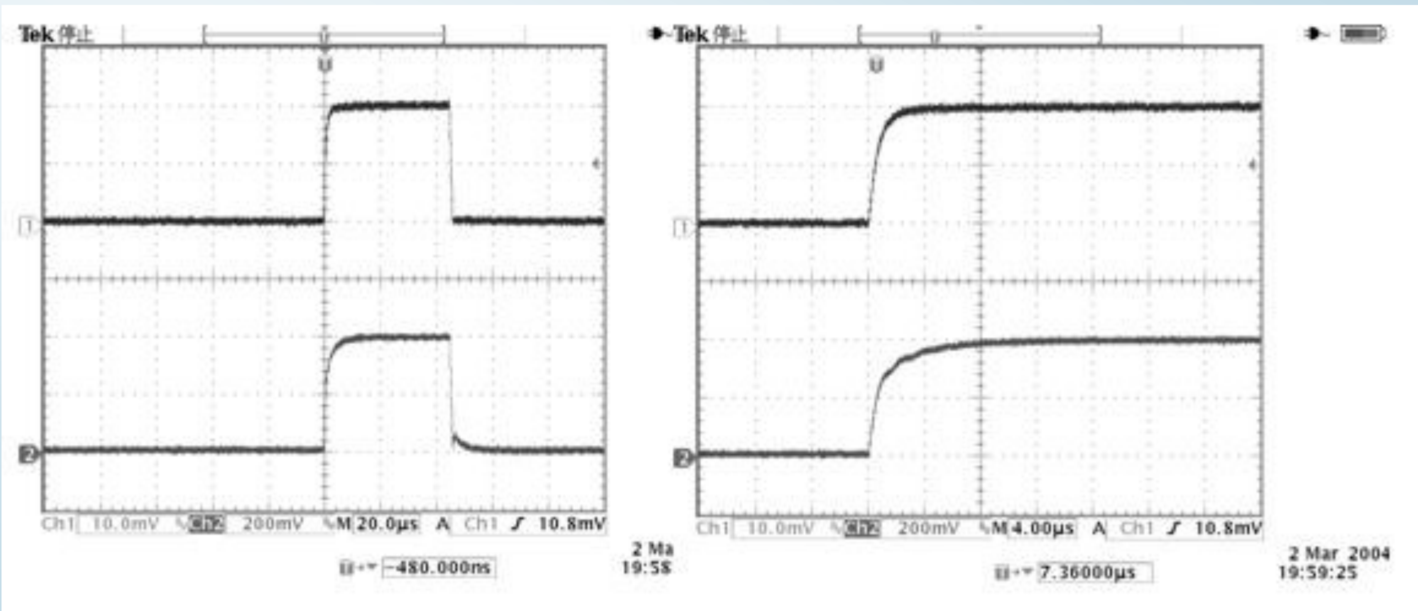
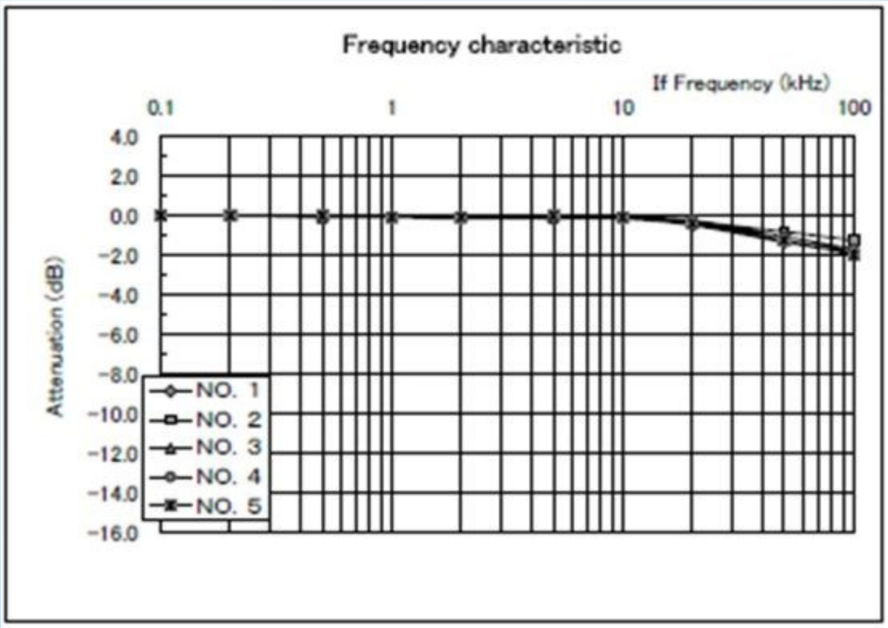


Example of Tamura CS Response Time: L06P400S05

[Response Time] Open loop Hall Effect Sensors

Another key feature of the open loop hall effect CS is the ability of the sensor to “track” of “follow” a fast input current waveform The fastest being a step function with a fast input rise time, or rate of change of current. The rate of change of current , dv/dt, is the time duration from 10% to 90% of the input signal. Open loop hall effect current sensors are able to respond to these high speed signals in less than 5ųsec.



Frequency Bandwidth is the range of sine wave frequencies that can be reproduced with a defined maximum attenuation (loss of output).

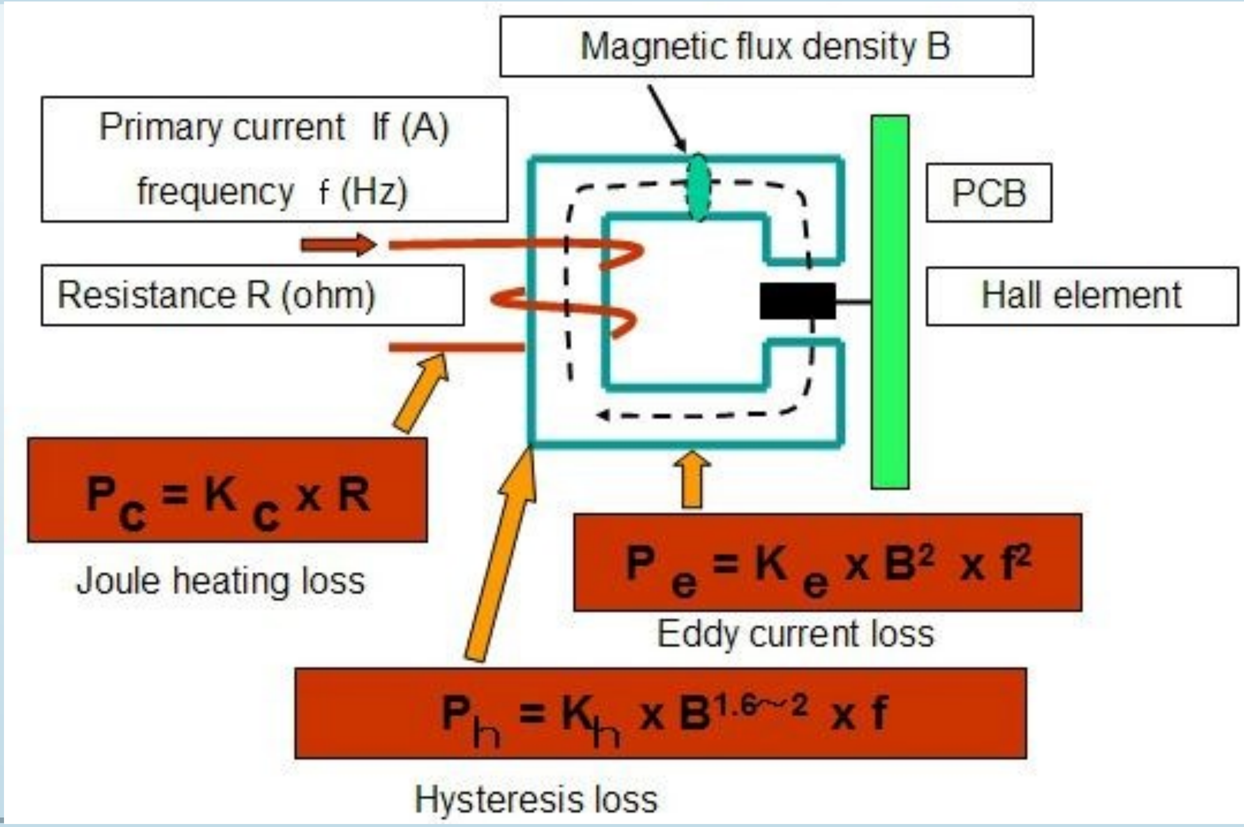
The frequency bandwidth of open loop current sensors is –3dB@50kHz small signal as the rated primary current must be de-rated at high frequency due to eddy current heating of the magnetic core.

Typically for open loop hall effect current sensors , the attenuation is the –3dB, as show on data sheets

[Frequency Bandwidth]

Open loop Hall Effect Sensors

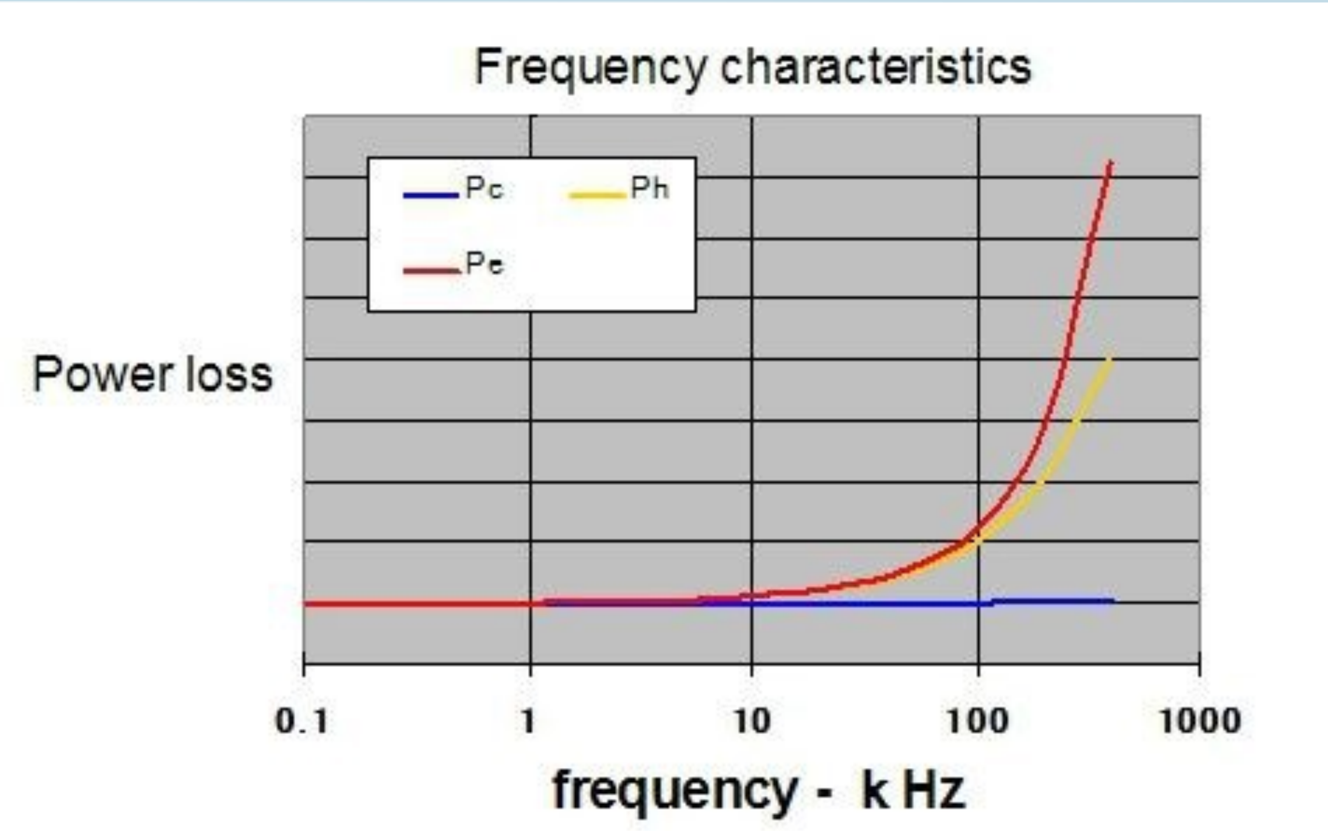
Frequency bandwidth or frequency response is another important feature of the open loop hall effect current sensor and is an indication of the ability of the current sensor to accurately measure high frequency input signals with minimal loss in fidelity and attenuation. Small signal currents with frequencies over 50kHz can be measured with less than 3dB of the attenuation.



[Heat Generation Mechanism]

Open loop Hall Effect Sensors

The small signal current limitation in the frequency response of the open loop current sensor is do to a combination of Joule heating plus frequency induced eddy current and hysteresis losses inherent in the magnetic core material.



Power Loss Analysis

Open loop Hall Effect Sensors

This graphs shows the total power loss increases as the frequency increase with conventional SiFe (Silicon Steel) magnetic core materials, which is why the measured current must be de-rated at higher frequency.

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Inverters

UPS

Smart Meter

Solar Power Generation Systems

- Industrial Robots
- Automation Devices
- Welding Machines
- Laser Cutting Machines
- Elevators

- Power Supply
- Wind Power System
- Fuel Cell Systems

[Applications]

Open loop Hall Effect Sensors

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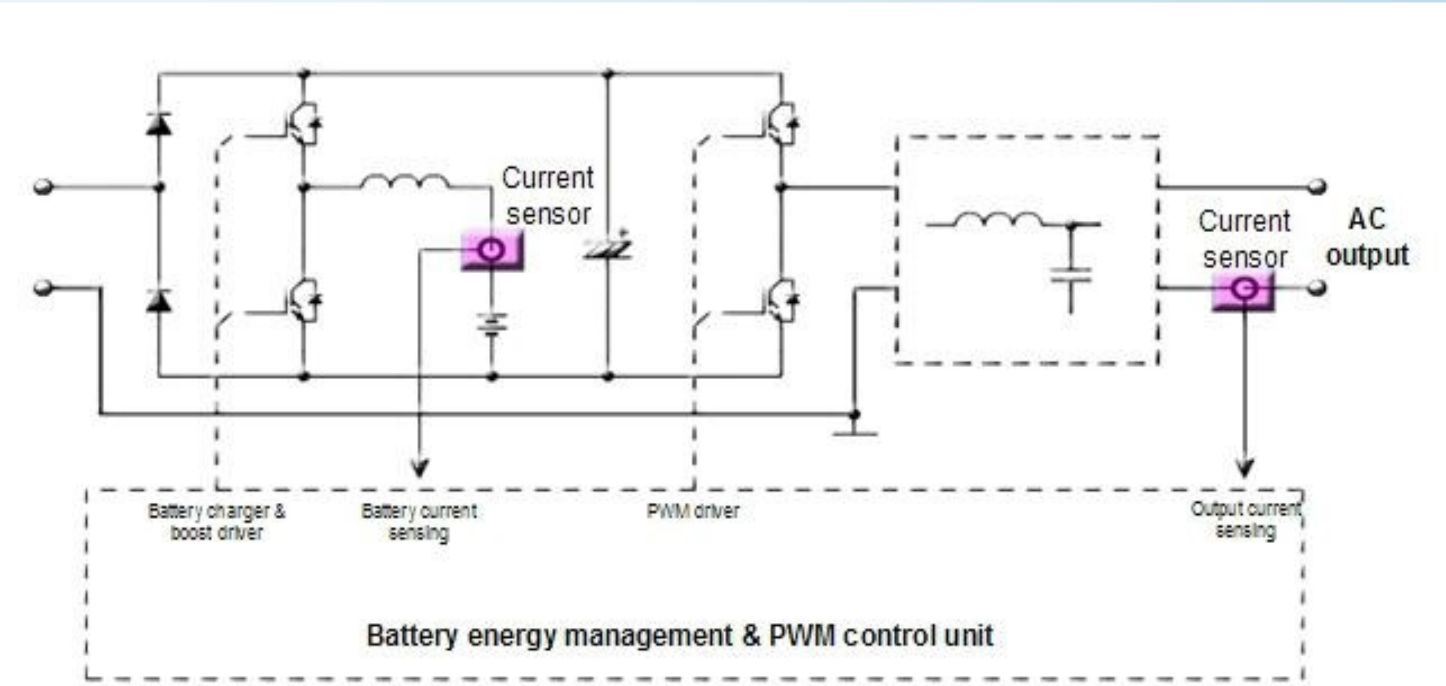
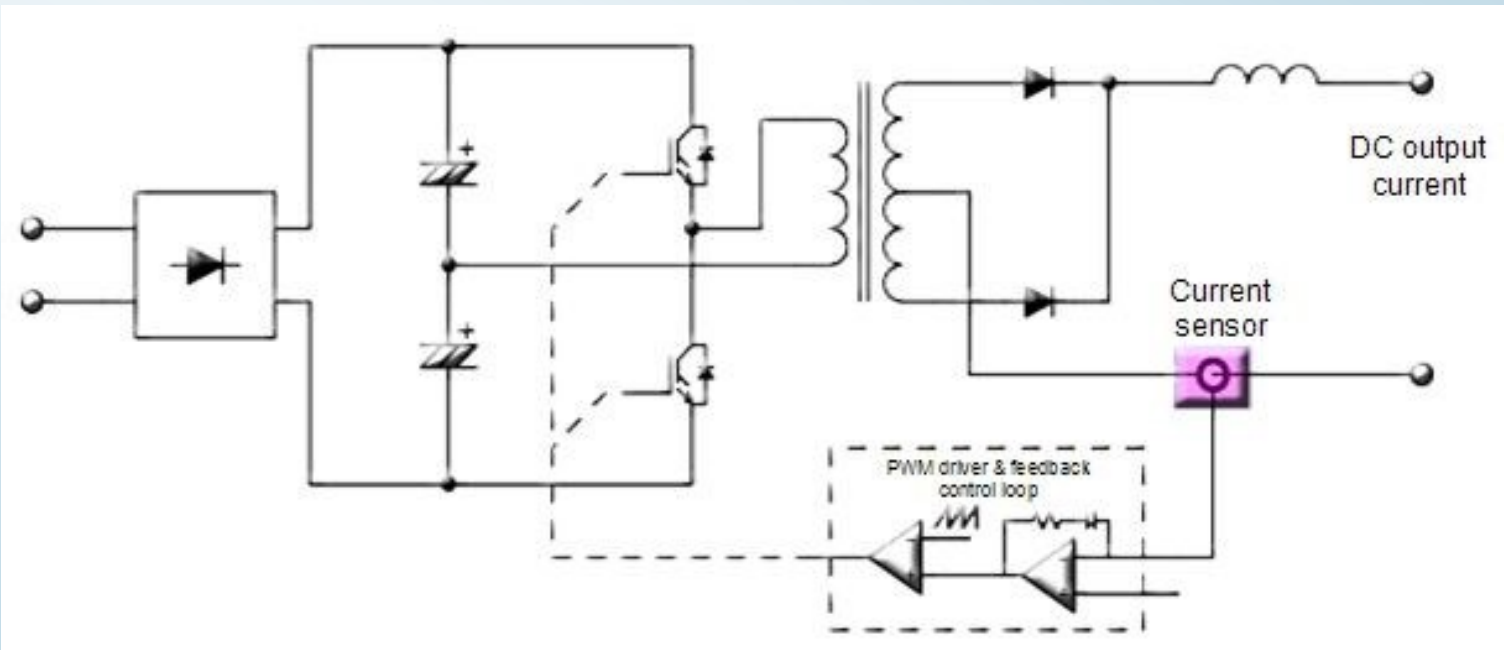
UPS - Uninterruptable Power Supply



[Applications] Open loop Hall Effect Sensors

Hall effect current sensors are used in battery energy management systems to control charge and discharge current and in the PWM (Pulse Width Modulated) to control system output current control.

Welding Machines



[Applications]

Open loop Hall Effect Sensors

The hall effect current sensor is used in the welding application shown here to provide a current proportional to the output signal to the PWM driver and feed-back control loop.

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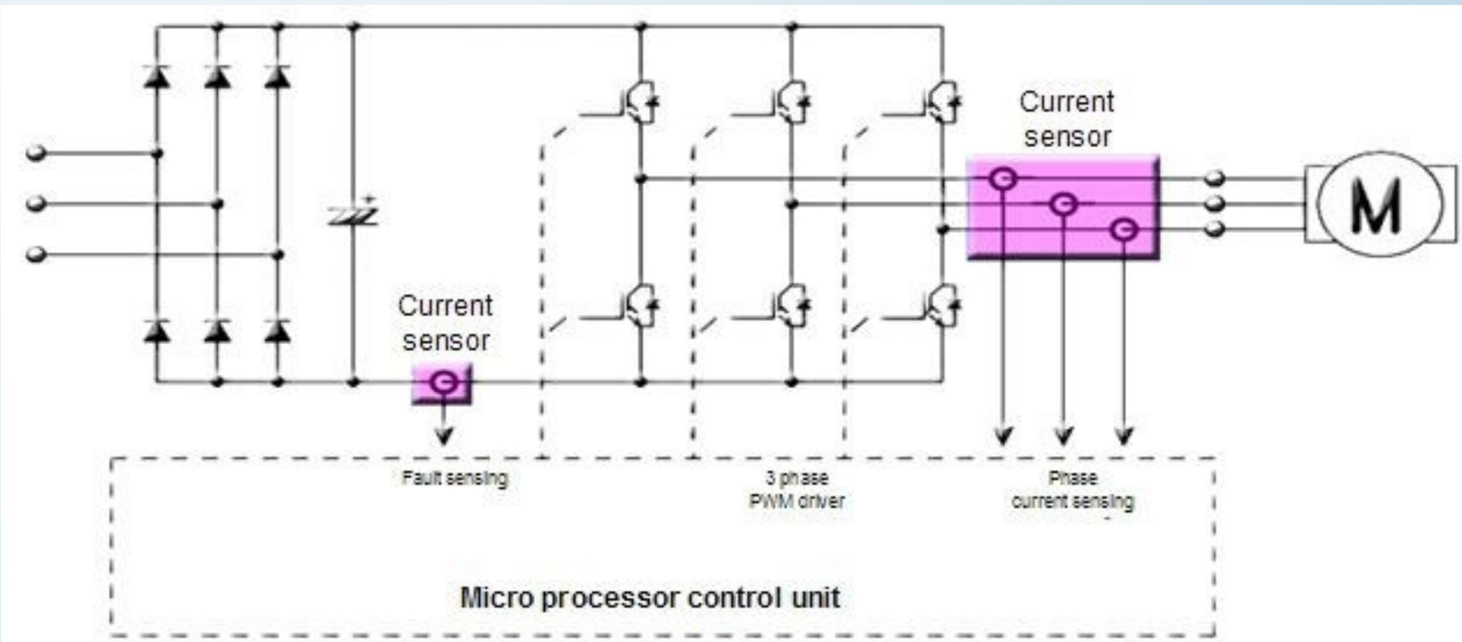
Inverter & AC Motor Drives



[Applications]

Open loop Hall Effect Sensors

In another application, hall effect current sensors are used in the DC link section of AC and inverter motor control systems for fault detection and in the output circuit for phase current control.

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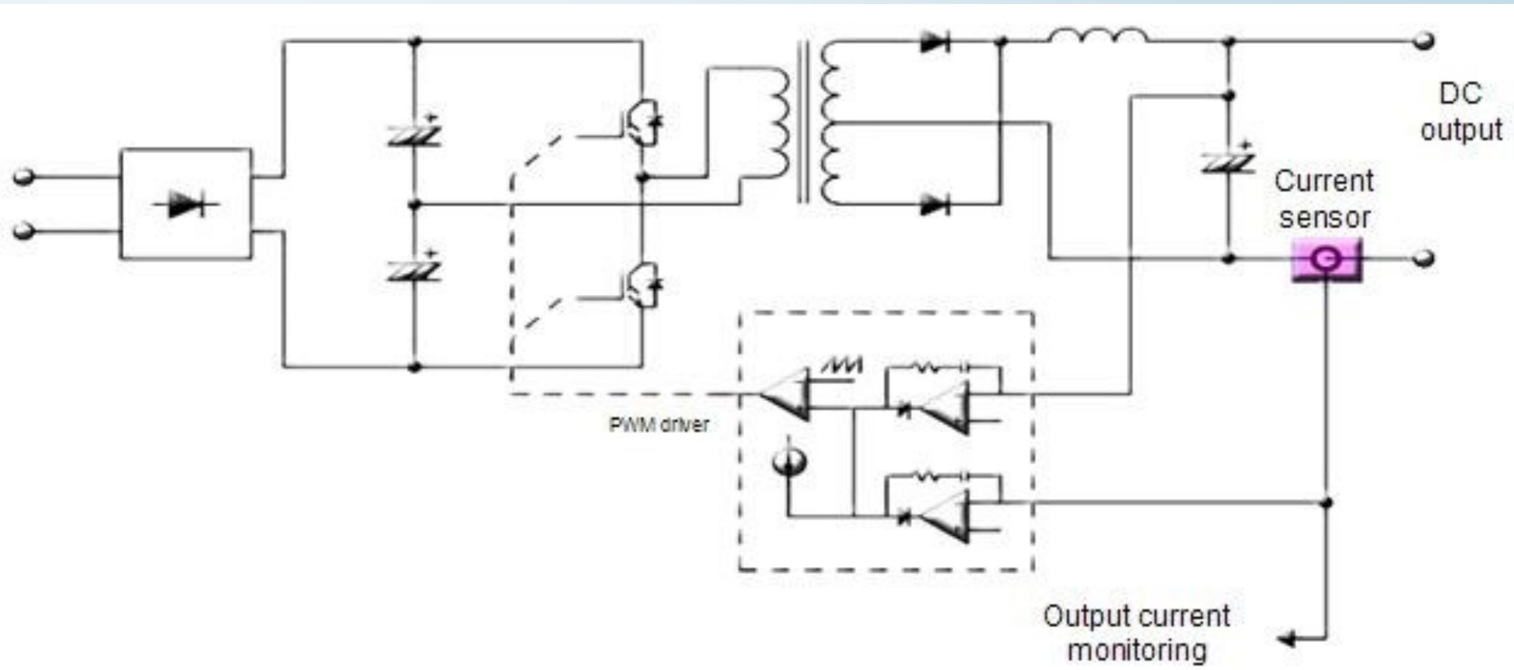
Power Supplies



Applications

Open loop Hall Effect Sensors

In the AC/DC bulk power conversion power supply shown in this slide, the hall effect current sensor is used to provide feedback proportional to the DC output current to the PWM driver control circuit.

L18P***S05 , L18P***S12 , L18P***D15

The L18P series open loop hall effect current sensor is available in 10 rated currents ranging from 3A to 60A & PSU options of +5VDC, +12VDC and ±15VDC.

The features include single and dual power supply operation , good accuracy (~1%) , and fast response time (≤ 5ų sec). The L18P series is PCB mounted with a multi-turn integrated primary conductor rated for up to 30A and a bus bar configuration rated for 40A-60A.

The L18P series, as with other open loop current sensors, has an instantaneous voltage output. The output of the L18P***D15 current sensor is 4V at rated current, where as the L18P***S05 & L18P***S12 output consists of the zero offset voltage of 2.5VDC + 1.5VDC at rated current for an instantaneous output of 4.0 VDC. The L18P***S05 gain can be set to provide an output per the alternate industry standard of 2.5VDC + 0.625VDC at rated current for an instantaneous output of 3.125VDC.

[Series Details L18 Series]

Open loop Hall Effect Sensors

- +5,+12,±15 VDC power supply
- Accurate
- Fast Response
- Voltage Output
- PCB mount
- Integrated Primary
- Wide Range
- Single Channel

L07P***S05 , L07P***D15 Dual Channel

The L07P series open loop hall effect current sensor is a dual channel device available in seven rated currents ranging from 3A to 30A and PSU options of +5VDC and ±15VDC. The features include single and dual power supply operation, good accuracy (~1%) and fast response time (≤ 5ųSec). *The L07P series* is PCB mounted with a multi-turn integrated primary conductor rated up to 30A. *The L07P series*, as with other open loop current sensors has an instantaneous voltage output. The output of the L07P***D15 current sensor is 4V at rated current, whereas the L07P***S05 output consists of the zero offset voltage of 2.5VDC+1.5VDC at rated current for an instantaneous output of 4.0VDC. This series gain can be set to provide an output per the alternate industry standard of 2.5VDC+0.625VDC at rated current for an instantaneous output of 3.125VDC. The L07P dual channel feature allows for simultaneous input of two rated currents for use in phase and differential current measurements.

Series Details

[**L 07 Series**]

Open loop Hall Effect Sensors

- +5,±15 VDC power supply
- Accurate
- Fast Response
- Voltage Output
- PCB mount
- Integrated Primary
- Wide Range
- Dual Channel
- Differential Current Measurement

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L03S***D15 , L33S***D15 , L34S***D15

Tamura open loop current sensors are available with an aperture suitable for cable and/or bus bar type primary conductors. The aperture also allows the addition of multiple primary turns or amp-turns (At) to be wound through the current sensor. This allows for improved measurement of lower primary current. Therefore a 1A x 100 turns = 100A-turns; 25Ax4turns = 100A-turns; and 100Ax1turn=100A-turns. Considering a current sensor with a 100A rated current by winding additional primary turns the current sensor output for 1A increases from 40mV to 4V and for 25A from 1V to 4V with the indicated ampere-turns.

Series Details
[L 03 Series]

Open loop Hall Effect Sensors

- ±12 VDC~±15VDC power supply
- Accurate
- Fast Response
- Wide measurement range
- Voltage output
- Panel mount
- Aperture

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