Tamura Closed Loop Hall Effect Current Sensors

- **AC , DC , & Complex Currents**
- **Galvanic Isolation**
- **Fast Response**
- **Wide Frequency Bandwidth**
- **Quality & Reliability**
- **RoHs Compliance**

Closed Loop Hall Effect Sensors are sometimes referred to in several ways : Zero-Flux Sensor, Compensation Sensor, DC-CT or Null Sensor. It is fundamentally a feed-back element used in a control system that provides a very accurate current measure-ment as a means to optimize system performance.

[Overview]

Closed loop Hall Effect Sensors

The following presents the relative advantages of the closed loop Hall Effect current sensors as high quality and reliability current sensors available in industry standard package styles. The sensors also provide fast response, galvanic isolation and high accurate measurement of DC and high frequency AC currents.

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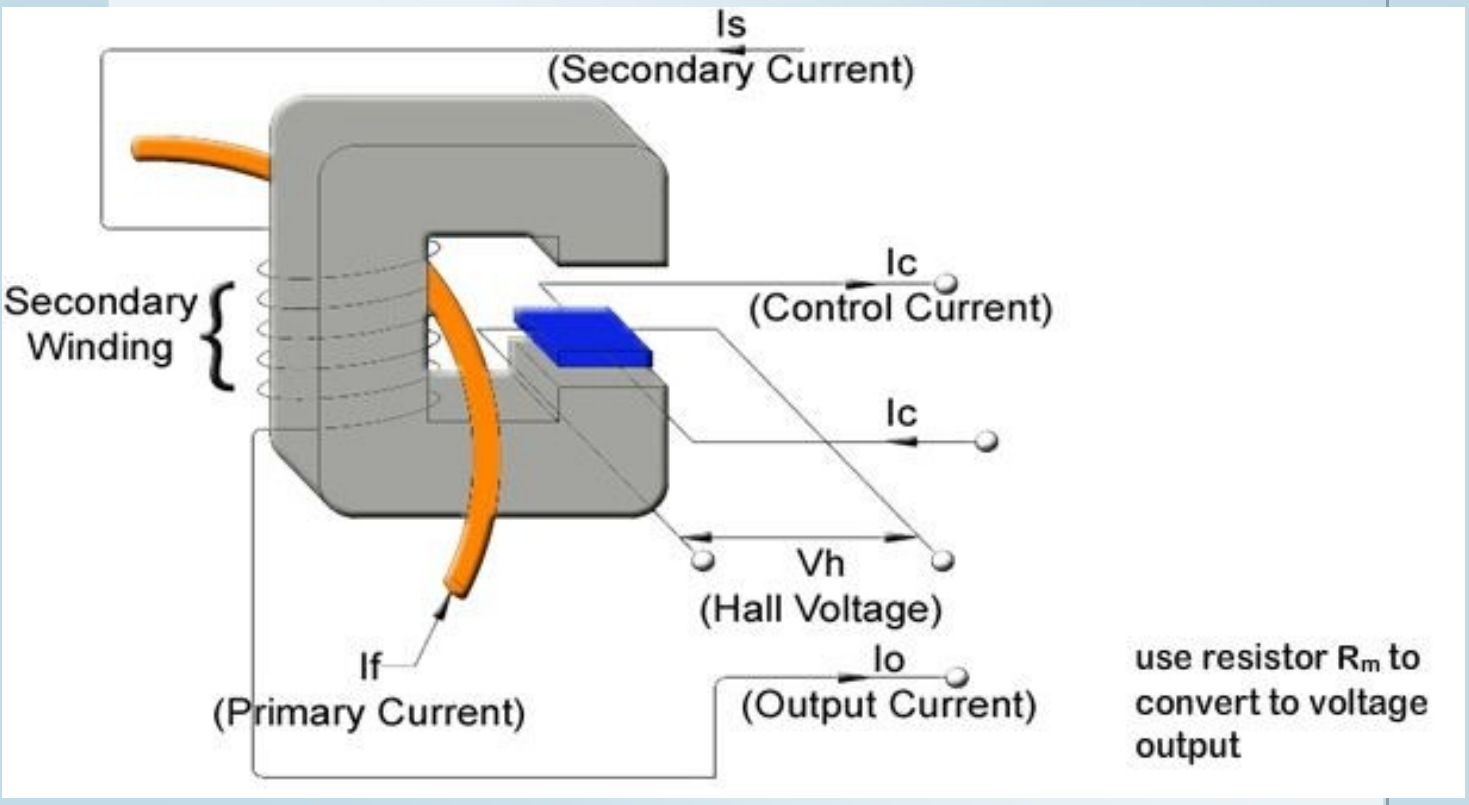
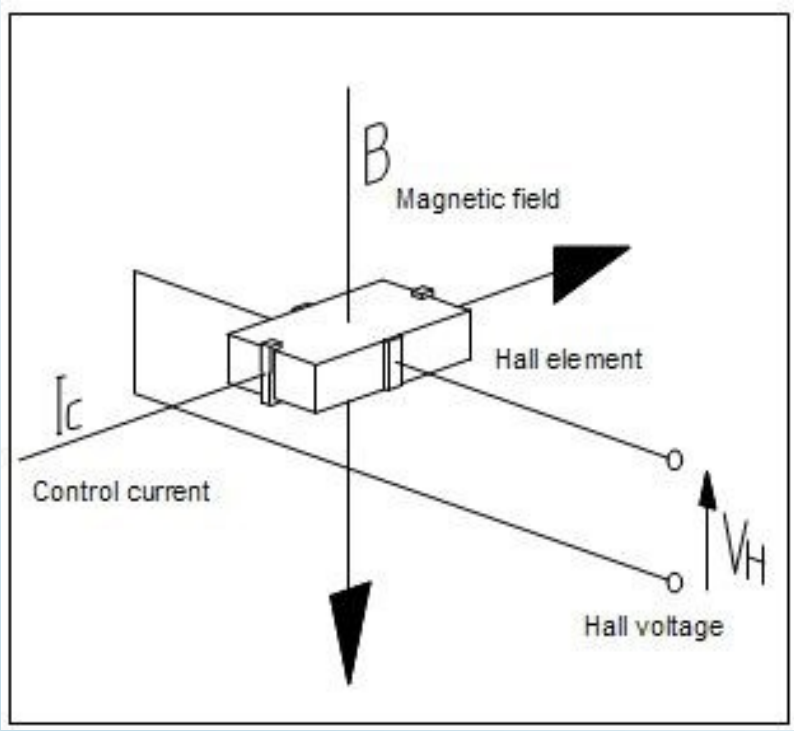


[How it works]

Closed loop Hall Effect Sensors

The magnetic flux generated by the primary current (If) is balanced or compensated by a current generated in the secondary winding. This compensation current is generated by signal conditioning electronic circuitry using the output of the Hall Element. The compensation current is then an exact, or instantaneous representation of the primary current divided by the number of turns in the secondary winding.



- **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]

Closed loop Hall Effect Sensors

The Hall Effect element is a four terminal semiconductor device typically fabricated from InAs material, which is selected for the material's sensitivity to a magnetic field. 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 VH is further signal conditioned and used to control the secondary current. The secondary current is driven through the secondary winding to generate the counter-flux needed to cancel the flux generated by the primary current.

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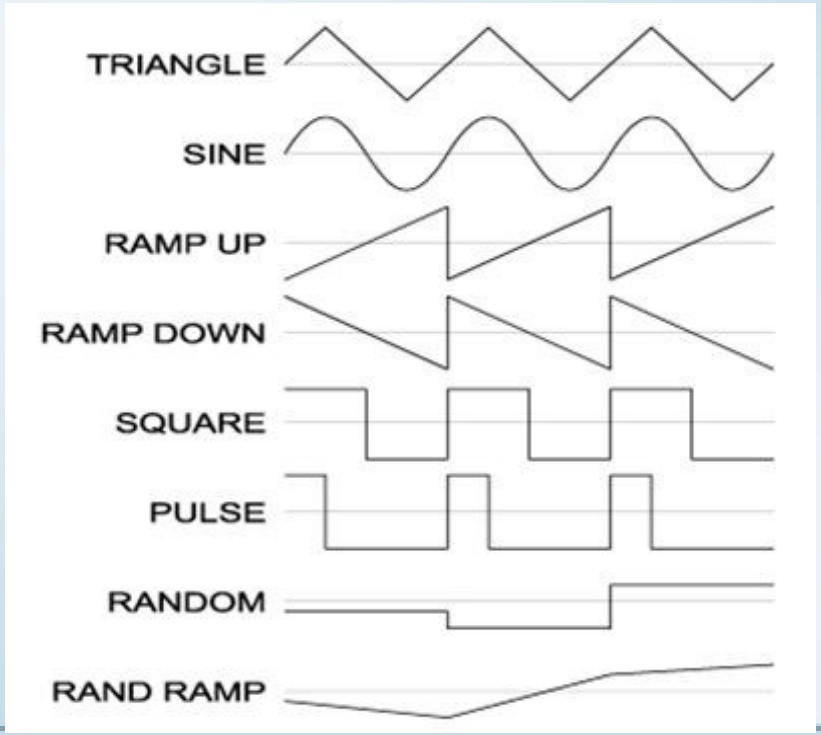
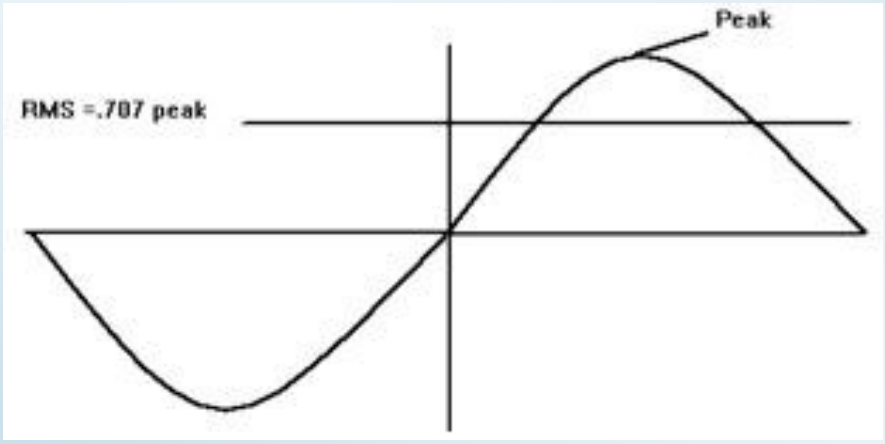


[Waveforms]

Closed 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

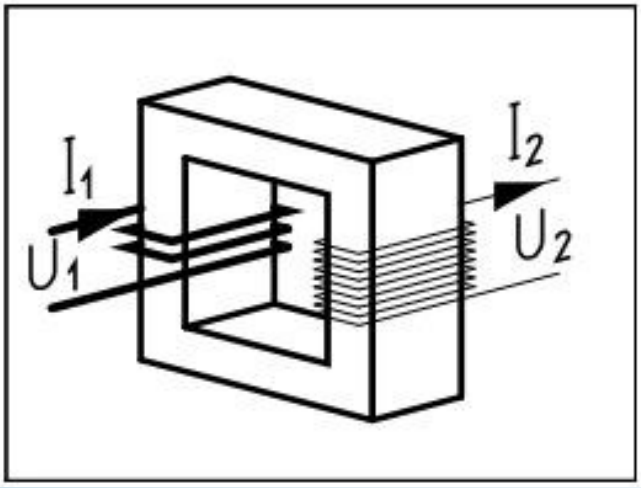
= I peak / √ 2

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]

Closed loop Hall Effect Sensors

Closed loop hall effect current sensor specifications define the input current as the rated, primary or nominal current rating of the sensor as a DC or RMS current. The output or secondary current is rated in instantaneous current, in either DC of AC. The output current tracks the input current exactly, there is no RMS conversion made by the current sensor.



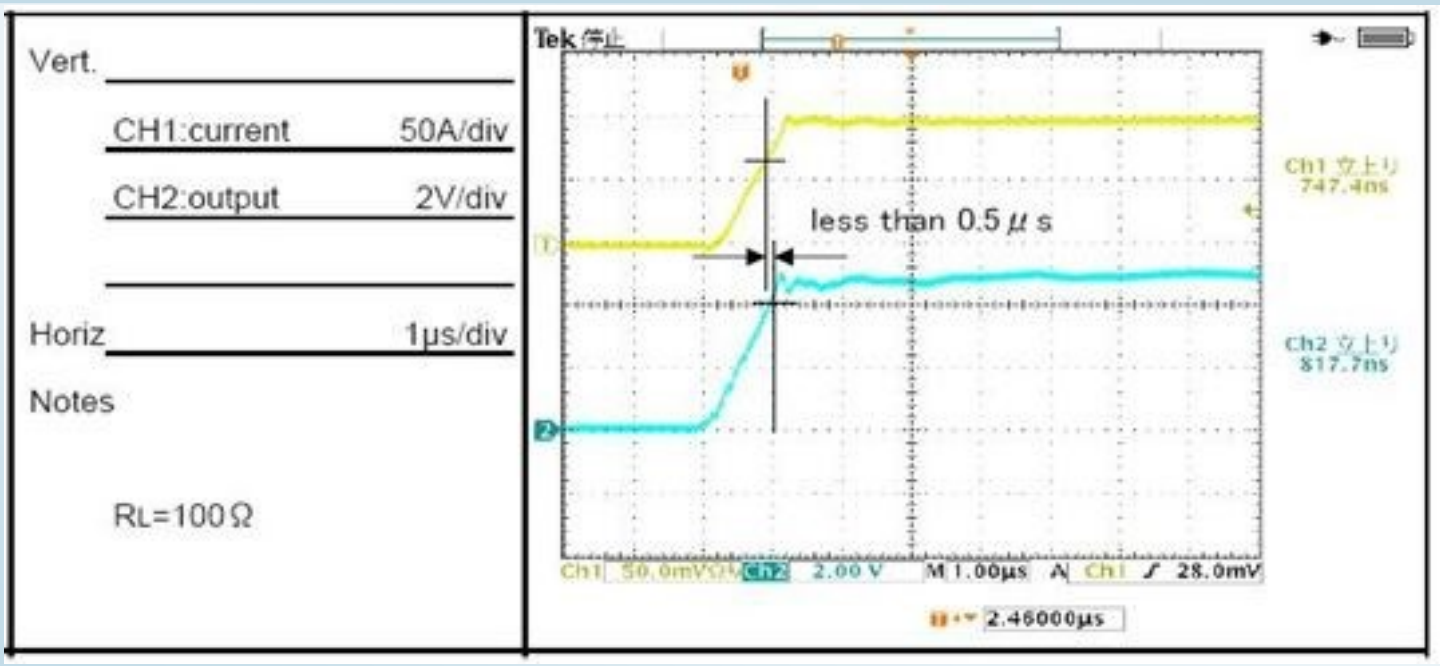
Two electrical circuits are in galvanic isolation if there is no physical contact between their electric conductors; energy exchange occurs between the two circuits by the magnetic field.

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]

Closed loop Hall Effect Sensors

Two electrical circuits are in galvanic isolation if there is no physical contact between their electric conductors and energy exchange occurs between the two circuits by their magnetic fields. In Hall effect current sensors, the design and construction allow a guaranteed voltage withstanding and insulation resistance rating, which are confirmed by rigorous testing. Galvanic isolation is major factor in the selection of Hall Effect closed loop current sensors over other current measurement techniques.

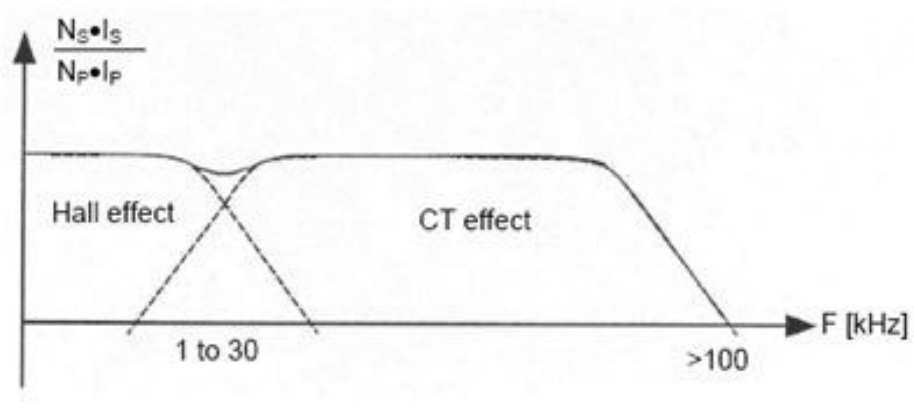


Example of Tamura CS Response Time:
S23P50 / 100D15

[Response Time]

Closed loop Hall Effect Sensors

Another key is its ability to track or follow fast rising input current waveforms with minimal phase delay. The rate of change of current per unit time or di/dt of the typical input signals are on the order of µSec and the sensor must be able to measure in the same order of magnitude. The above example shows the input signal and the sensor output signal; the time between the point the input signal reaches 90% of its final value and the output reaches 90% of its final value is one way to measure response time. (Note: Tamura Specifications define the response time to be 10% of input signal to 90% of output signal) No matter how response time is defined , current sensors are able to respond to there high speed signals in les than 1µSec



Frequency Bandwidth is greater than 100kHz due to the current transformer (CT) effect. (-1dB)

Frequency bandwidth of frequency response is another important feature of the closed loop hall effect 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.

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

Typically for open loop hall effect current sensors , the attenuation is the –1dB or –3dB, as show on data sheets

[Frequency Bandwidth]

Closed loop Hall Effect Sensors

The closed loop Hall Effect sensor's frequency bandwidth capability derives from a combination of the electronics and current transformer effect. As seen in the graph at lower frequencies, the frequency response is due to the hall effect and signal conditioning electronics. At higher frequencies, frequency bandwidth is limited by the current transformer effect provided in the secondary winding.

Primary Input Current (oI) A

Secondary Output Current (oI) A

IpNp=IsNs relates Input to Output Current (where N=# of turns)
Expressed in terms of Output Current:

Is=IpNp/Ns
For Np=1 turn & Ns = 2000 turns

Is = Ip/2000 **For Tamura Ip=If & Is= Is**

[Basic Transformer Equation] Closed loop Hall Effect Sensors

Whether the input of a hall effect sensor is a sine, square, or complex waveform, the relationship between input and output (transfer function) is defined by what is know as the Transformer Equation. The primary current multiplied by the number of primary turns is equal to the secondary current multiplied by the number of secondary turn. In other words, the output current is proportional to the input current and the proportionality is a constant equal to the number of primary turns divided by the number of secondary turns (Is-Ipx(Np/Ns)) Tamura defines Ip (primary current) as Ir (rated current).

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**
- **AC/DC drives**

[Applications]

Closed loop Hall Effect Sensors

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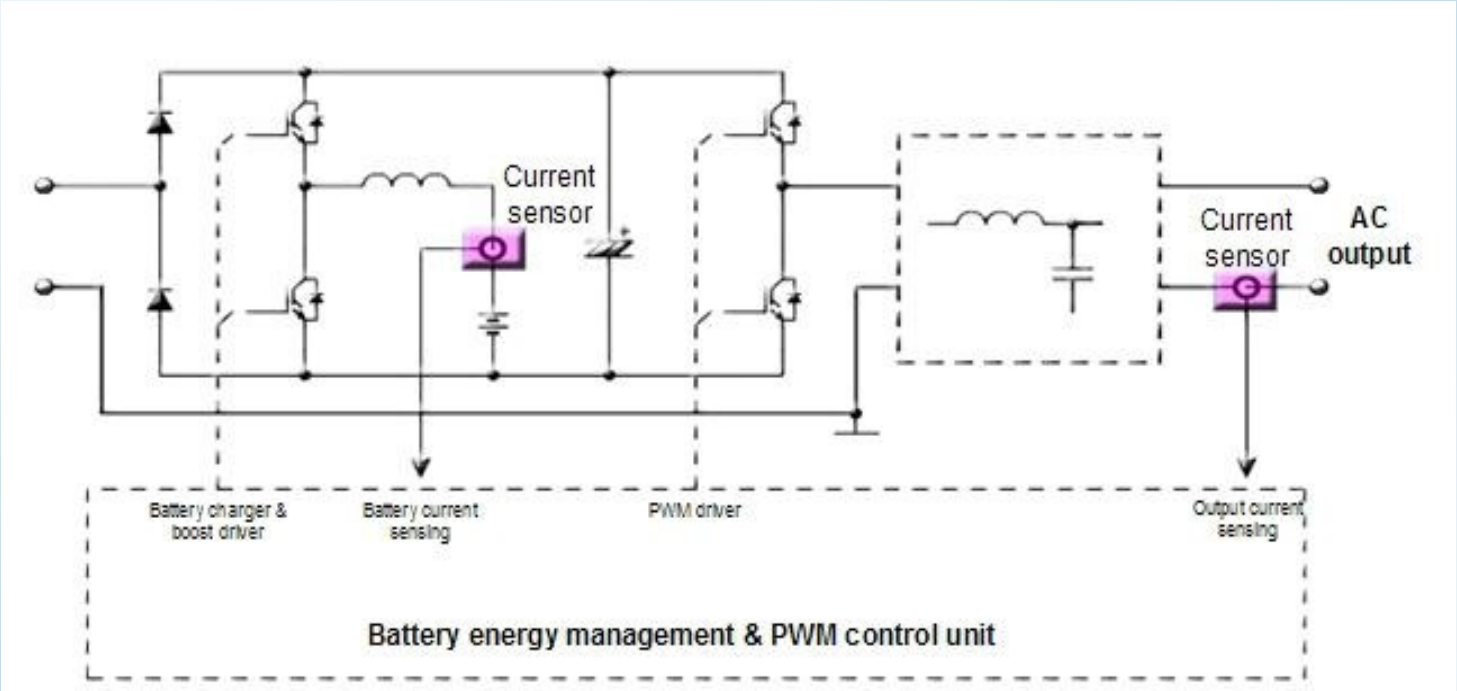
UPS - Uninterruptable Power Supply

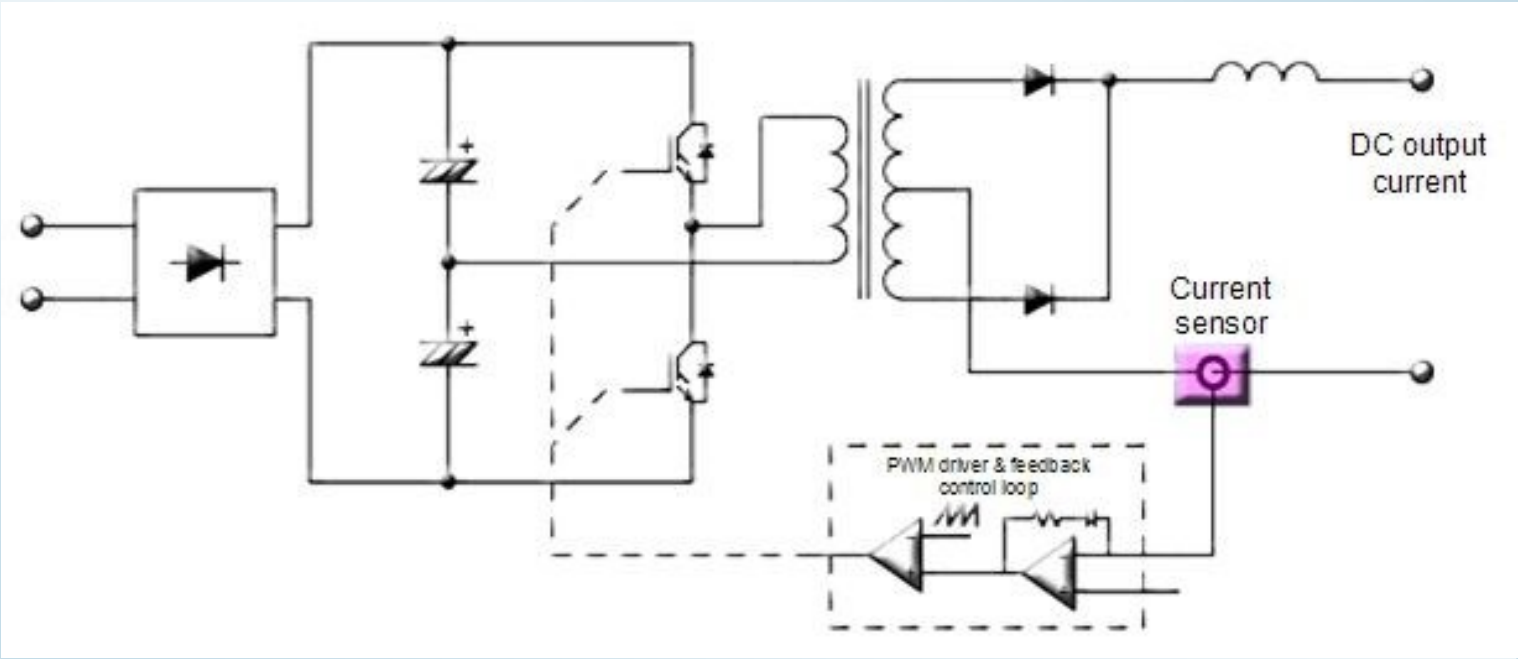


[Applications]

Closed 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

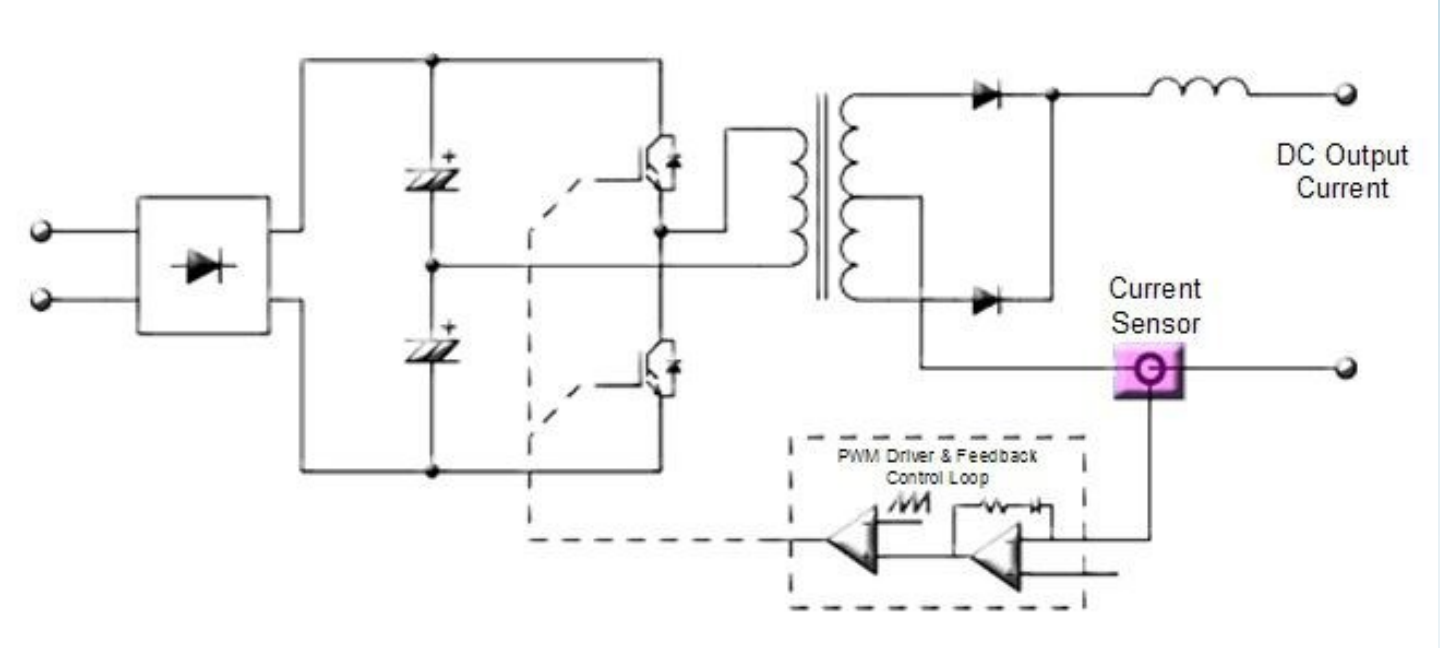


[Applications]

Closed 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.

Inverter & AC Motor Drives

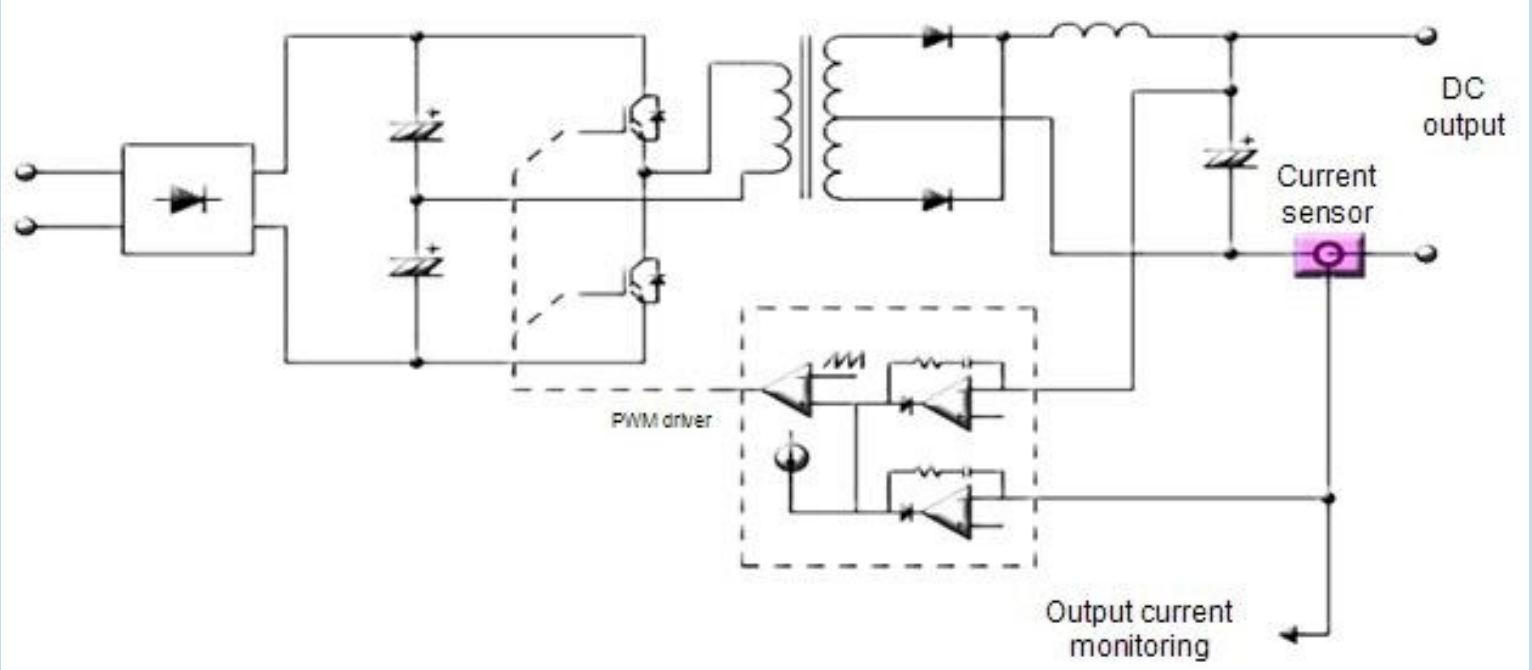


[Applications]

Closed loop Hall Effect Sensors

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 circuits for phase current control.

Power Supplies



[Applications]

Closed 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.

S22P0006S05 , S22P015S05 , S22P025S05

The S22P series closed loop Hall Effect current sensor is available in 3 current ranges : 6A , 15A and 25A. Its features include : single power supply operation , high accuracy (better than 1%) and fast response time)less than 1μs). The S22P series is PCB mounted with an integrated primary conductor configurable for 1-2-3 primary turns. Instead of the instantaneous current output typical of other Closed Loop Hall Effect Current Sensors , the output of the S22P series is an instantaneous voltage due to an internal measuring resistance which scales the output to 0.625V at the nominal rated current

Series Details

S22P*S05 Series

Closed loop Hall Effect Sensors

- +5 VDC power supply
- High Accuracy
- Fast Response
- Voltage Output
- PCB mount
- Integrated Primary
- Multi Range

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S23P50 / 100D15

The S23P series is available in 2 models ; the 23P50 / 100D15 with 2000 turns of secondary winding , and the S23P50 / 100D15M1 with 1000 turns of secondary winding. The 23P series includes a dual power supply operation, high accuracy better than 1% , and less than 1µs response time. The 23P is PCB mounted with an integrated primary conductor. The instantaneous current output of the S23P series is proportional to the input current divided by the number of secondary turns and can be converted to an instantaneous voltage by adding an external measuring resistance selected from the range listed on the data sheet.

Series Details

S23P*D155 Series

Closed loop Hall Effect Sensors

- ±12.±15 VDC power supply
- High Accuracy
- Fast Response
- Current Ouput
- PCB mount
- Integrated Primary
- 1000..2000 turns

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