amploc
current sensors

Engineers' Reference Handbook

The Hall Effect Theory

The Hall Effect principal states that when a current carrying conductor is placed in a magnetic field, a voltage will be generated perpendicular to the direction of the field and the flow of current. Consider Figure 1 in which a constant current is passed through a thin sheet of semiconducting material to which are attached output connections at right angles to the current flow. With zero magnetic field current distribution is uniform and there is no potential difference at the output contacts.

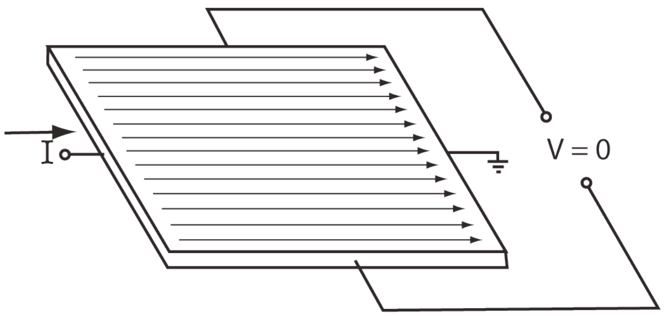


Figure 1

When a perpendicular magnetic field is present, as illustrated in Figure 2, the current flow is distorted. The uneven distribution of electron density creates a potential difference across the output terminals. This voltage is called the Hall voltage.

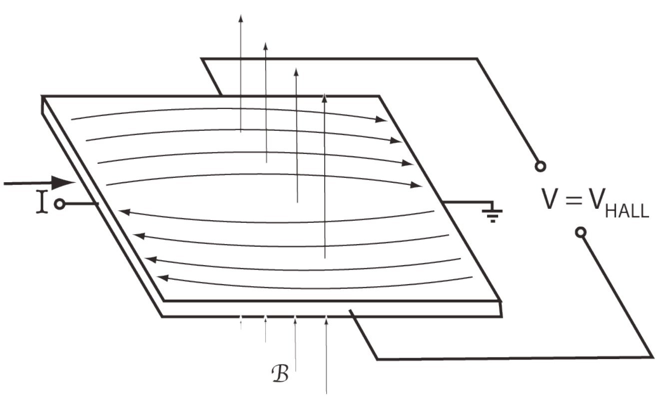


Figure 2

A practical equation that describes the interaction of the magnetic field, current and Hall voltage is:

$$V_H = k \bullet I \bullet B \sin Ø$$

Where:

- constant k is a function of the geometry of the Hall element, the ambient temperature and the strain placed on the Hall element.
- B sin Ø is the component of magnetic field perpendicular to the sheet.

If the input current is held constant the Hall voltage will be directly proportional to the strength of the magnetic field.

The Hall voltage is a low level signal of the order of 20 to 30 microvolts in a magnetic field of one gauss. A signal of this magnitude requires a low noise, high impedance, moderate gain amplifier. Figure 3 shows a block diagram of a typical Hall current sensor.

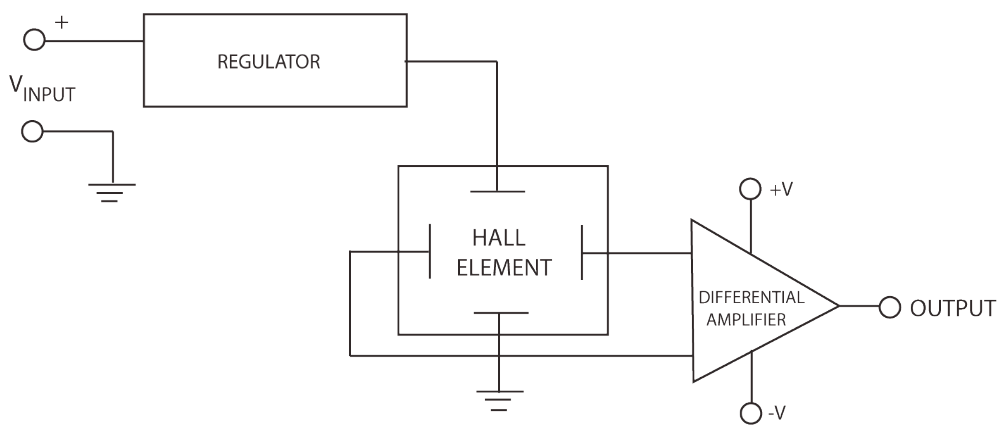


Figure 3

The magnetic field sensed by the Hall plate can be either positive or negative. As a result, the output of the amplifier will be driven either positive or negative, thus requiring both plus and minus power supplies. This concept is illustrated graphically in Figure 4.

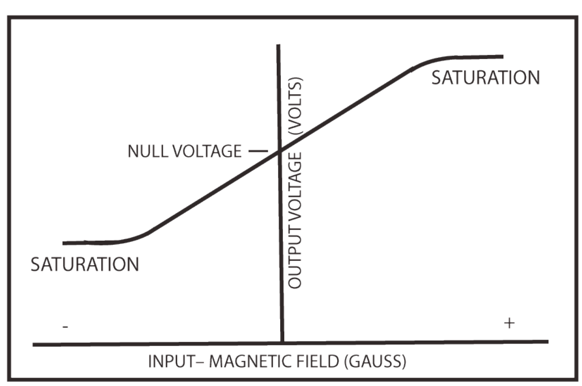


Figure 4

Sensed currents that exceed the rating of the sensor and drive it out of the linear operating range cause saturation. Saturation takes place in the amplifier and in the magnetic circuit. Excessive currents will not damage the Hall sensing element.

OPEN LOOP SENSORS

Open loop transducers are capable of measuring dc, ac and complex waveform currents with galvanic isolation. Advantages are low power consumption, small size and low weight. Insertion losses are virtually zero and current overloads cause no damage to the sensor . The PRO and AMP series sensors in this catalog are open loop sensors and can be operated from single voltage or dual voltage power supplies. Ratings range from 5A to 300A.

An open loop sensor is illustrated schematically in Figure 5. It shows a Hall generator mounted in the air gap of a magnetic core. A current carrying conductor placed through the aperture of the core produces a magnetic field proportional to the current magnitude. The core concentrates the magnetic field around the Hall generator, the output of which is fed into an amplifier.

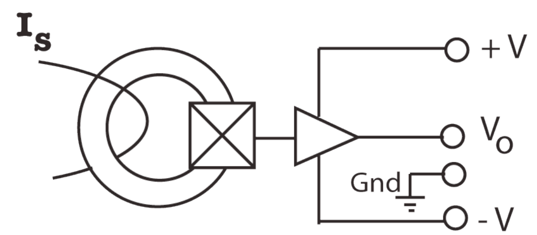


Figure 5

The linearity of the open-loop sensor is determined by the characteristics of the magnetic core and the Hall generator. Offset voltage drift over temperature is determined primarily by the temperature sensitivity of the Hall generator .

The frequency bandwidth of closed loop sensors is limited by Eddy current and hysterisis losses in the magnetic core. Eddy current losses depend upon the thickness of the laminations, the peak magnetic induction and frequency.

Hysterisis losses are proportional to frequency and peak magnetic induction. Bandwidth is also determined by the characteristics of the amplifier and compensation circuits.

CLOSED LOOP SENSORS

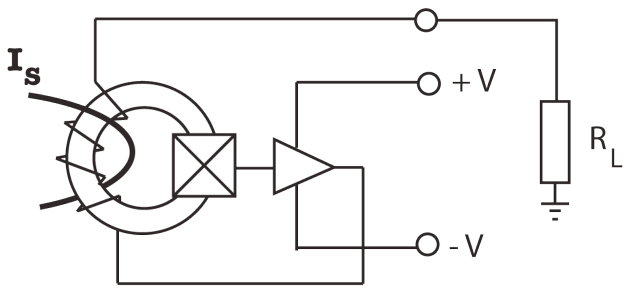


Figure 6

Figure 6 is a block diagram of a closed loop sensor. It shows a Hall generator mounted in the air gap of a magnetic core, a coil wound around the core and a current amplifier. A current carrying conductor placed through the aperture of the core produces a magnetic field that is proportional to current magnitude.

The Hall generator output voltage is boosted by a high gain amplifier, the output of which is fed into a push-pull driver stage that drives the coil wound in series opposition on the magnetic core. Thus creating a magnetic field equal to and opposite to the field of the sensed current: maintaining the core flux level near zero. The output of the closed loop sensor is proportional to the aperture current and the number of turns of the coil. A sensor with a 1000 turn coil will provide an output of 1 mA/A. The output current signal is converted to a voltage by connecting a resistor between output of the sensor and ground. Output voltage can be scaled by selecting various resistor values.

This technique allows significant improvements in sensor performance by eliminating the influence of non-linearities in the magnetic core and by reducing the effects of temperature sensitivity in the Hall element.

Most closed loop sensors require dual power supplies.

The AMPLOC <u>CS</u> series of closed loop sensors are available in ratings from 25A to 300A.

TRUE RMS TO DC CONVERTER

Most current sensors produce outputs that are instantaneous representations of the measured currents. For complex or ac waveshapes there may be a requirement to convert the outputs to true rms values.

RMS converters available from Analog Devices are designed to accept complex input waveforms containing ac and dc components. They can be operated from either a single or dual supplies. The converters are designated AD536A. The devices draw less than 1 mA of quiescent supply current, making them ideal for battery-powered applications. They exhibit >1MHz bandwidth and <.5% accuracy. (www.analog.com)

CREATE -12Vdc FROM +12Vdc

Texas Instrument's PT78NR112 creates a negative output voltage from +12Vdc input. These easy-to-use, 3-terminal, Integrated Switching Regulators have maximum output power of 5 watts and a negative output voltage that is laser trimmed. They also have excellent line and load regulation. They can be used with closed loop sensors that reguire ±12Vdc power supplies. (www.ti.com)

DEFINITIONS

Response Time
Response time is defined as the delay between the instant the sensed current reaches 90% of its final value and the instant the sensor output signal reaches 90% of final value as illustrated in Figure 7. For open loop sensors response time and di/dt ratings depend primarily upon the slew rate of the amplifier.

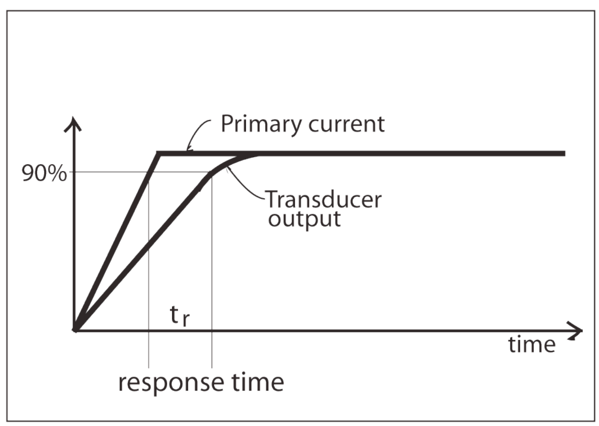


Figure 7

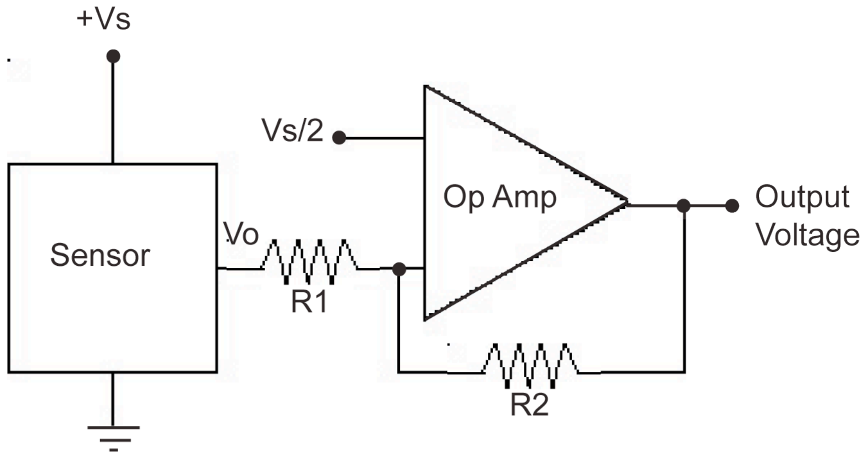
di/dt accurately followed
The linear rate of change in current that the sensor can accurately measure.

Linearity
Output deviation from a straight line response to the current being measured.

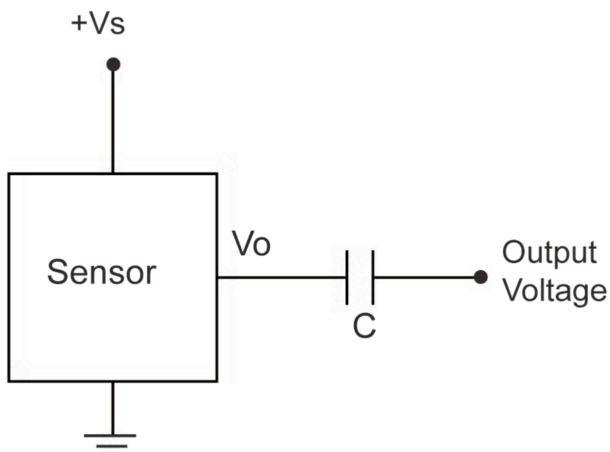
APPLICATION NOTE

Interface circuits commonly used with AMPLOC current sensors

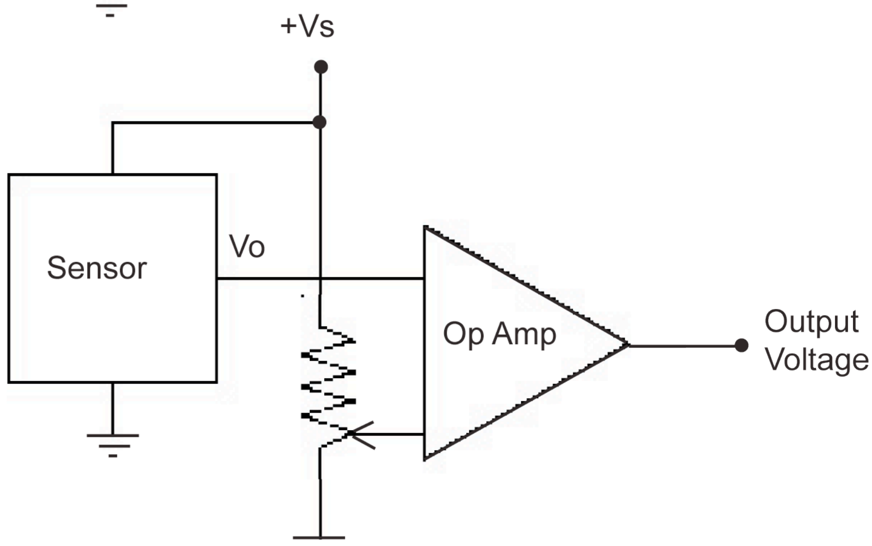
Output proportional to sensed current.



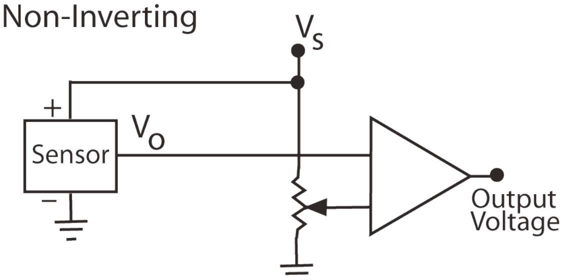
Output proportional to ac current.



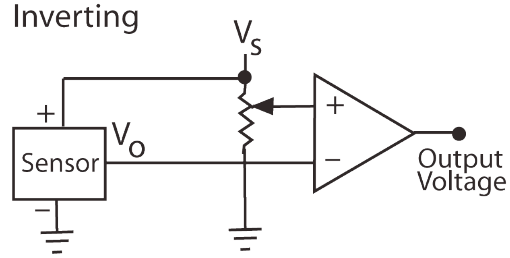
Digital swtch with adjustable operate point.



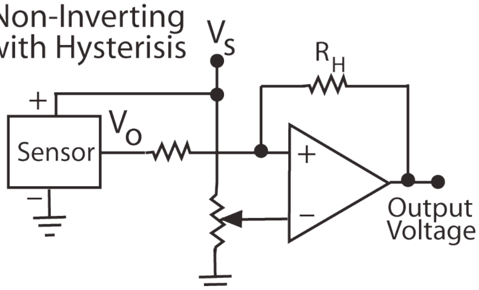
Non-Inverting



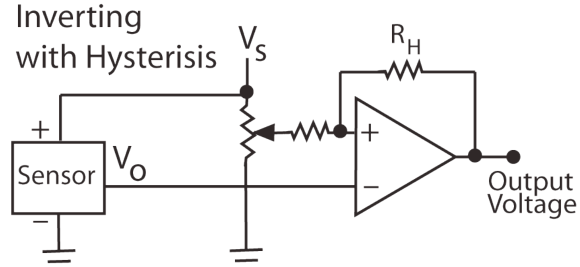
Inverting



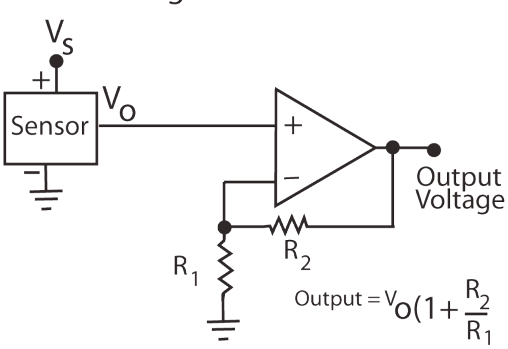
Non-Inverting with Hysteresis



Inverting with Hysteresis

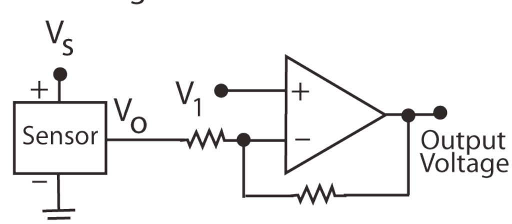


Non-Inverting



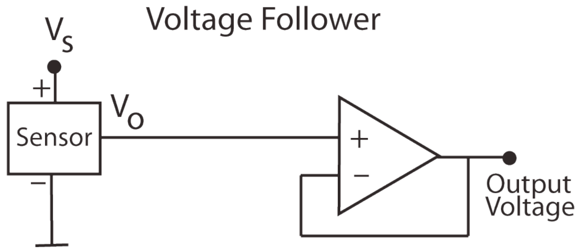
Output = $V_O(1+\frac{R_2}{R_1})$

Inverting



Output = $(V_1 - V_O)\frac{R_2}{R_1} + V_1$

Voltage Follower



AMPLOC SENSORS

AMPLOC current sensors provide galvanic isolation and are capable of measuring dc, ac and complex waveforms.

• For best overall electrical performance consider the <u>CS</u> closed loop sensor series.

These sensors are characterized by:

√ Accuracy 0.4% - 0>8%
√ Linearity 0.1% - 0.2%
√ Low temperature drift
√ Response time 0.4μsec - 0.8μsec
√ Bandwidth dc to 250kHz
√ di/dt to 70A/μsec

• For smallest size and lowest weight consider the <u>AMP</u> series. These open loop sensors are encapsulated in tough polypropylene and are practically impervious to chemical attack. The terminals are gold plated. They are the smallest linear current sensors on the market. In terms of cost/performance they offer great value.

• For operation in temperatures ranging from -55C to + 125C and where size is important consider the <u>PRO</u> series. They are open loop sensors that are utilized in satellites, aircraft and undersea applications. These sensors are light weight and low cost.

ampLoc current sensors

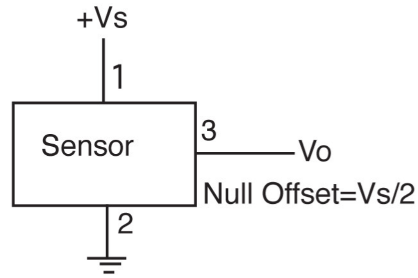
AMP25, AMP50, AMP100

25,50,100 Ampere Ratings

ampLoc.com

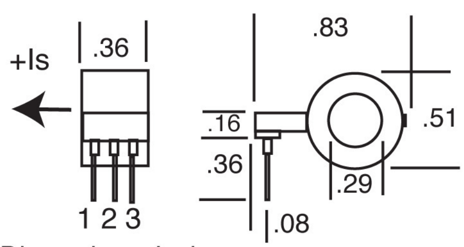
Hall effect linear sensors. –55C to +125C

Sensor Style	Fig.	Sensed Current (Amps peak)	Vs= +5V ΔVo at peak rated current **	Vs= +5V Sensitivity mV/A **
AMP25	1	25	.925V	37
AMP50	1	50	1.14V	23
AMP100	1	100	1.9V	19



** proportional to Vs

Figure 1



Dimensions: Inches
Terminals: .025 sq., 0.1 spacing.
Weight: 3 grams.

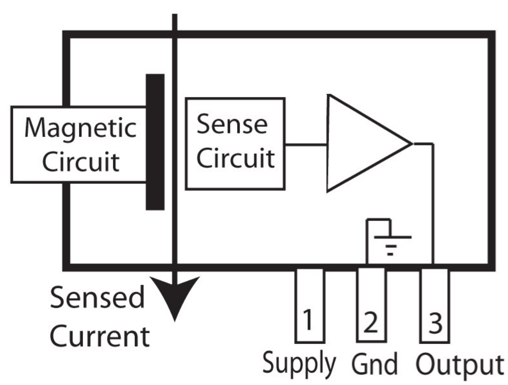
AMP25 Linear to 60A.
AMP50 Linear to 90A.
AMP100 Linear to 120A.

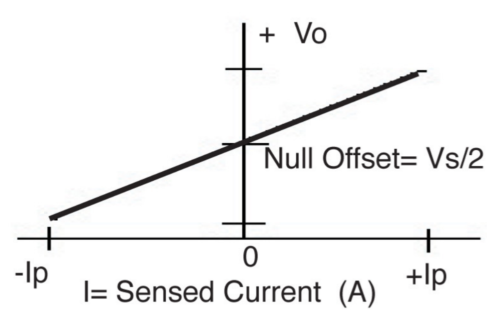
Caution:Do not reverse supply voltage polarity.

ELECTRICAL CHARACTERISTICS

Supply voltage, Vs.. ....+4.5 to +10 Vdc
Supply Current..................................... 10mA max.
Output Current....................................... 2mA max.
Offset Voltage, Vo (Sensed I = 0A.). Vs/2±2%
Output Voltage, Vo is proportional to Vs.
Temperature Error
Null................... .... .03%/C
Gain... .03%/C

Temperature Range......................... –55C to +125C
Response Time.. 3μSec.
Linearity (Full Scale).. 1%
Accuracy (Full Scale)....................................... ±2%
A.C. Hysterisis Error...................................... 0.5%





amploc current sensors

ZAP25, ZAP50, ZAP100

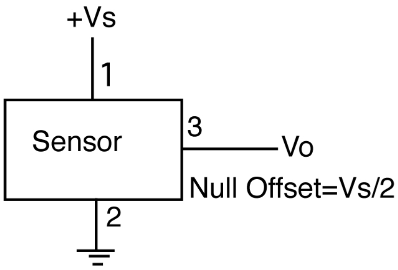
25,50,100 Ampere Ratings

RoHS Compliant

amploc.com

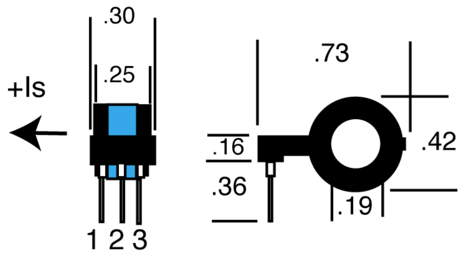
Hall Effect linear sensors (–55C to +125C)

Sensor Style	Fig.	Sensed Current (Amps peak)	Vs= +5V ΔVo at peak rated current **	Vs= +5V Sensitivity mV/A **
ZAP25	1	25	.9V	37
ZAP50	1	50	1.14V	23
ZAP100	1	100	1.9V	19

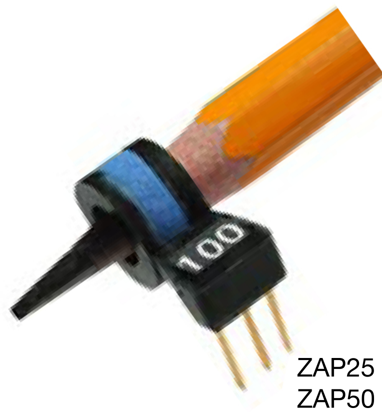


** proportional to Vs

Figure 1



Dimensions: Inches
Terminals: .025 sq., 0.1 spacing.
Weight: 1.5 grams.



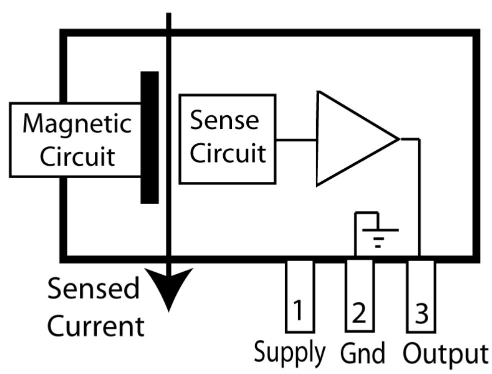
ZAP25 Linear to 60A.
ZAP50 Linear to 90A.
ZAP100 Linear to 120A.

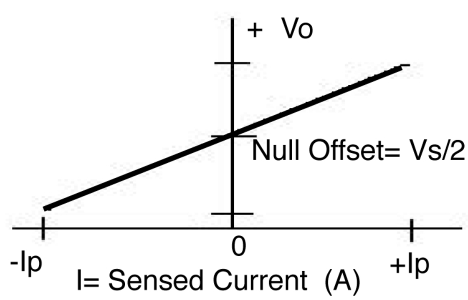
Caution:Do not reverse supply voltage polarity.

ELECTRICAL CHARACTERISTICS

Supply voltage, Vs.. ....+4.5 to +10 Vdc
Supply Current.................................... 10mA max.
Output Current..................................... 2mA max.
Offset Voltage, Vo (Sensed I = 0A.). Vs/2±2%
Output Voltage, Vo is proportional to Vs.
Temperature Error
Null.................. .... .03%/C
Gain... .03%/C

Temperature Range........................ –55C to +125C
Response Time... 3μSec.
Linearity (Full Scale)... 1%
Accuracy (Full Scale)...................................... ±2%
A.C. Hysterisis Error...................................... 0.5%





ampLoc
current sensors

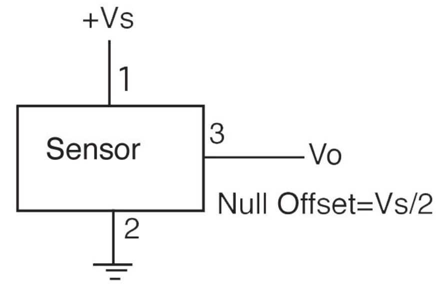
KEY100,AMP200, AMP300

100A , 200A , 300A ratings

amploc.com

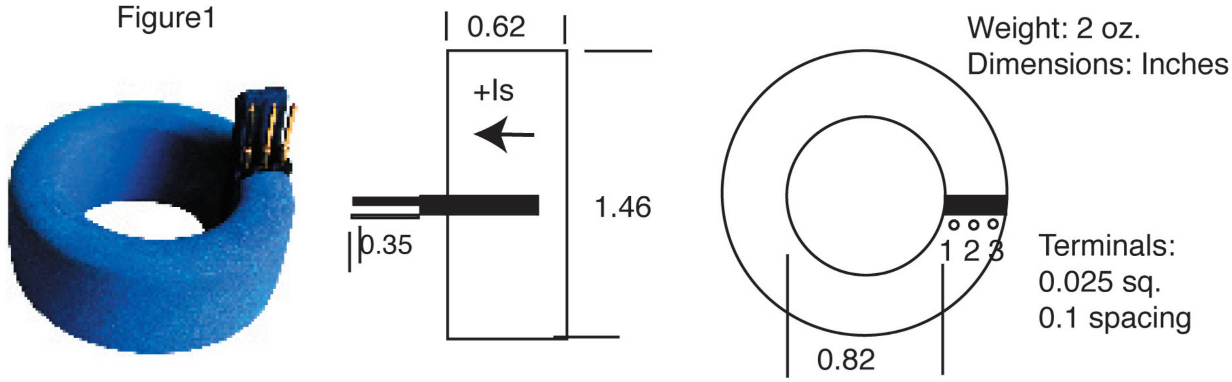
Hall effect linear current sensors. (-40C to +125C)

Sensor Style	Fig.	Sensed Current (Amps peak)	Vs= +5V ΔVo at peak rated current *	Vs= +5V Sensitivity mV/A *
KEY 100	1	100	1.59V	15.9
AMP 200	1	200	1.9V	9.5
AMP 300	1	300	2.38V	7.9

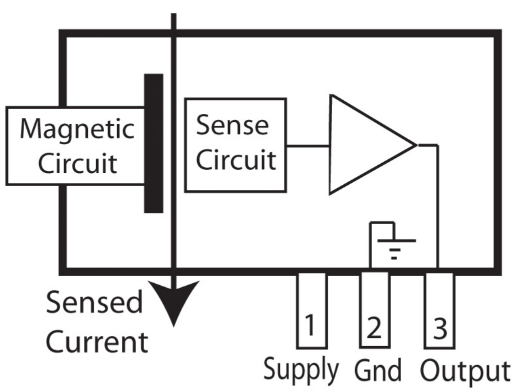


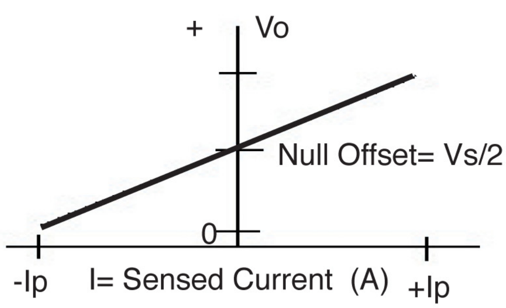
* proportional to Vs

Figure1



Mating connector: Samtec SSW-1-03-02-T-S-RA
or Molex 5051-04





Caution: Do not reverse supply voltage polarity.
Do not drop on cement floor.

ELECTRICAL CHARACTERISTICS

Supply voltage, Vs...............+4.5 to +10.0 Vdc
Supply Current......................... 10mA max.
Output Current.............................. 2mA max.
Offset Voltage, Vo (Sensed I = 0A.). Vs/2±2%
Output Voltage, Vo is proportional to Vs.
Temperature Error
Null.................. .... .03%/C
Gain.. .03%/C
Temperature Range................. -40C to +125C
Response Time.................................. 3μSec.
Linearity (Full Scale).................................. 1%
Accuracy (Full Scale)................................ ±2%

amploc
current sensors

ampploc.com

Closed Loop Sensor

Nominal Rating 50A rms — CS50-P

Electrical Data

- Nominal current(In) ±50A rms
- Current range 0~ ±400A peak*
- Nominal output current 50mA
- Turns Ratio 1000/1
- Measuring Resistance (Rm) ref. figure 1
- Overall accuracy at 25°C 0.5%
- Supply voltage ±12V ~ ±18V
- Current consumption 15mA + output current

* at ±18V power supply, Rm ≤ 1Ω, 25°C

Dynamic Performance

- Null offset current. Max.0.2mA (25°C)
- Thermal drift offset current Max. 0.25mA (0°C to 70°C)
- Linearity: better than 0.1%
- Response time better than 1μS
- di/dt: better than 50A/μS
- Frequency range: DC to 100KHz

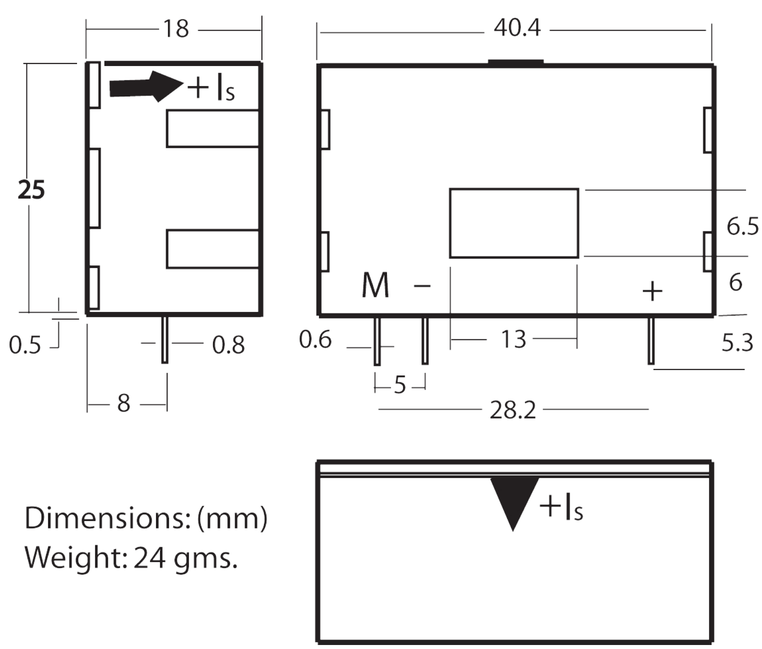
Figure1 Maximum value of the measuring resistance

At maximum input amp-turns (peak) / Supply voltage	50 A•T	100 A•T	300# A•T	400# A•T
±12V	70Ω	50Ω	–	–
±15V	200Ω	80Ω	5Ω	–
±18V	250Ω	100Ω	10Ω	1Ω

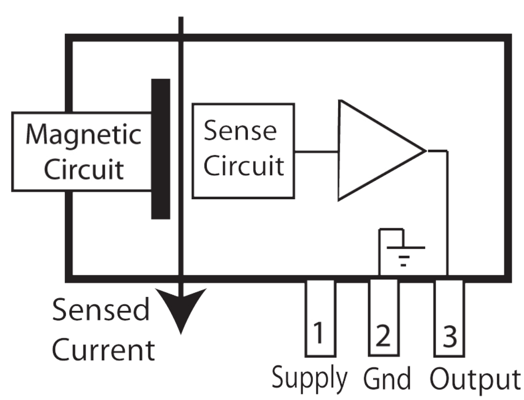
\# Derate according to duty cycle

General Data

- Sensor housing: insulated plastic case
- Fire-retardant feature: UL94V-O
- Isolation voltage: 5kV/50Hz/1min.
- Operating temperature: -25°C to +85°C
- Storage temperature: -40°C to +100°C
- A positive output current is obtained on terminal M when the input current flows in the direction of the arrow.
- Connect the measuring resistor Rm between terminal M and power supply ground. Output voltage= ImxRm



Dimensions: (mm)
Weight: 24 gms.



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current sensors

amploc.com

Closed Loop Sensor

Nominal Rating 100A — CS100A-P

Electrical Data

- Nominal current(In) ± 100A
- Current range 0~ ± 200A
- Nominal output current (Im) 50 mA
- Turns Ratio 2000/1
- Measuring Resistance (Rm) 0 ~100 Ω
- Overall accuracy at 25°C 0.5%
- Supply voltage ±12V ~ ±18V
- Current consumption 15mA + output current

Note

- Busbar temperature should not exceed 100°C .
- A positive output voltage is obtained on terminal M when the input current flows in the direction of the arrow.

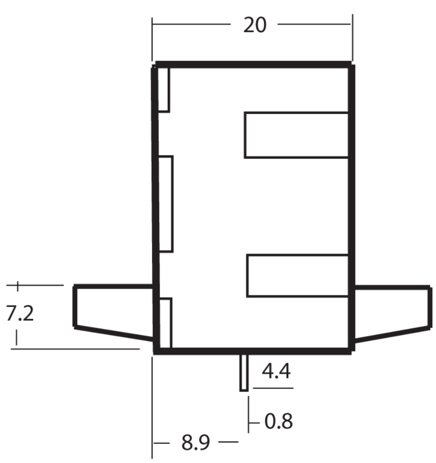
Dynamic Performance

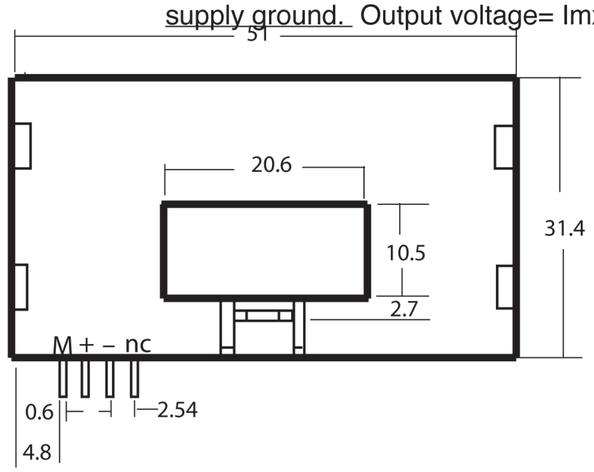
- Null offset current. Max.0.2mA (25°C)
- Thermal drift offset current Max. 0.3mA (-25°C to 85°C)
- Linearity: better than 0.1%
- Response time better than 0.5μS
- di/dt: better than 70A/μS
- Frequency range: DC to 250KHz

General Data

- Sensor housing: Fire retardant UL94V-O
- Isolation voltage: 5kV/50Hz/1min.
- Operating temperature: -25°C to + 85°C
- Storage temperature: -40°C to + 100°C

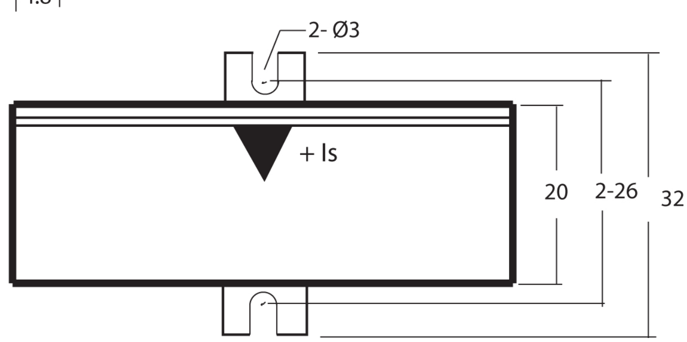
Connect the Measuring Resistor Rm between terminal M and power supply ground. Output voltage= ImxRm.





Dimensions:(mm)
Weight: 34 gms.

Mating connector:
Samtec SSW-1-03-02-T-S-RA



amploc.com

Closed Loop Sensor

Nominal Rating 200A rms **CS200A-P**

Electrical Data

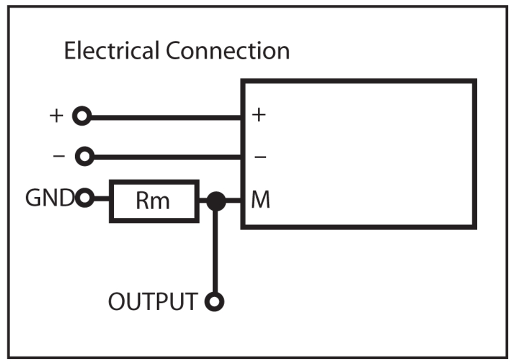
- Nominal current(In) ±200A rms
- Current range 0~ ±400A peak
- Nominal output current 100 mA
- Turns Ratio 2000/1
- Measuring Resistance (Rm) ref. f gure 1
- Overall accuracy at 25°C 0.5%
- Supply voltage ±12V ~ ±18V
- Current consumption 15mA + output current

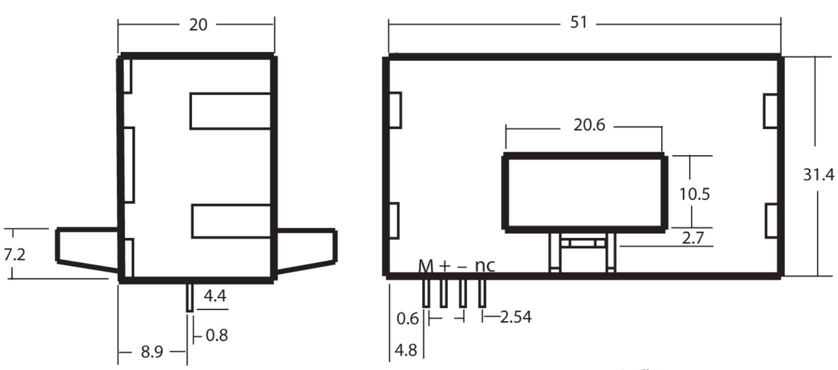
Figure1 Maximum value of the measuring resistance

At maximum input amp-turns (peak) / Supply voltage	200 A•T	300 A•T	A•T	A•T
±12V	15 Ω			
±15V	40 Ω	3Ω		
±18V				

Dynamic Performance

- Null offset current. Max.0.2mA (25°C)
- Thermal drift offset current Max. 0.3 mA (-25°C to 85°C)
- Linearity: better than 0.1%
- Response time better than0.6µS
- di/dt: better than 70A/µS
- Frequency range: DC to 250KHz



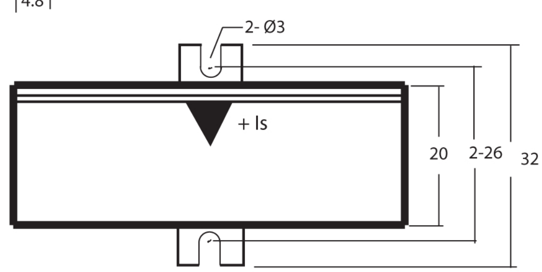


Note

- Busbar temperature should not exceed 100°C .
- A positive output voltage is obtained on terminal M when the input current flows in the direction of the arrow.

Dimensions:(mm)
Weight: 34 gms.

Mating connector:
Samtec SSW-1-03-02-T-S-RA



amploc current sensors

amploc.com

Closed Loop Sensor

Nominal Rating 300A rms — CS300-C

Electrical Data

- Nominal current(In) 300A rms
- Current range 0~ ±1200A peak**
- Nominal output current 150 mA
- Turns Ratio 2000/1
- Measuring Resistance (Rm) ref. f gure 1
- Overall accuracy at 25°C 0.5%
- Supply voltage ±12V ~ ±30V
- Current consumption 25mA + output current

** at ±30V power supply, Rm ≤ 1Ω, 25°C.

Dynamic Performance

- Null offset current. Max.0.2mA (25°C)
- Thermal drift offset current
  Max. 0.3 mA (-25°C to 70°C)
- Linearity: better than 0.1%
- Response time better than 1µS
- di/dt: better than 50A/µS
- Frequency range: DC to10

General Data

- Sensor housing: Fire retardant UL94-0
- Isolation voltage: 5kV/50Hz/1 min.
- Operating temperature: -25°C to + 85°C
- Storage temperature: -40°C to + 100°C

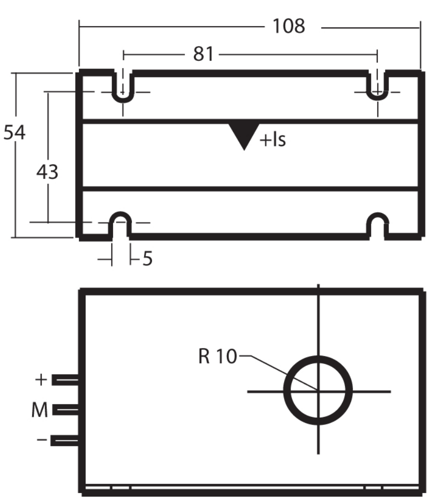
Note

- Busbar temperature should not exceed 100°C .
- A positive output voltage is obtained on terminal M when the input current flows in the direction of the arrow.

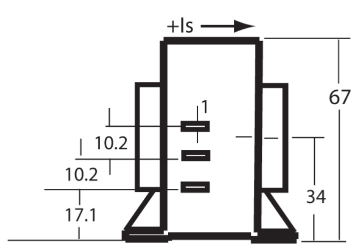
Fig. 1 Maximum value of measuring resistance

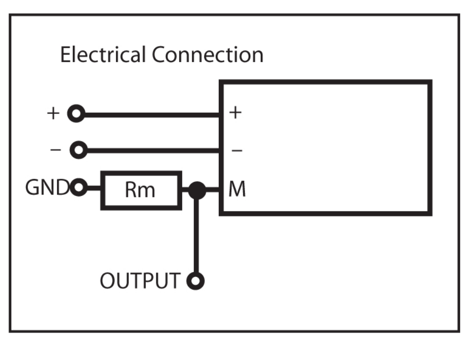
Supply voltage	At maximum input amp-turns (peak) 300 A•T	500 A•T	1000* A•T	2400* A•T
± 12V	50Ω	25Ω	–	–
± 15V	70Ω	30Ω	–	–
± 18V	90Ω	40Ω	–	–
± 24V	130Ω	65Ω	25Ω	–
± 30V	170Ω	90Ω	30Ω	1Ω

* Derate according to duty cycle.



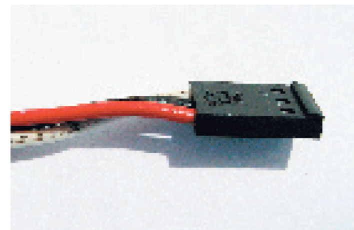
Dimensions:(mm)
Weight: 200 gms.





CONNECTORS

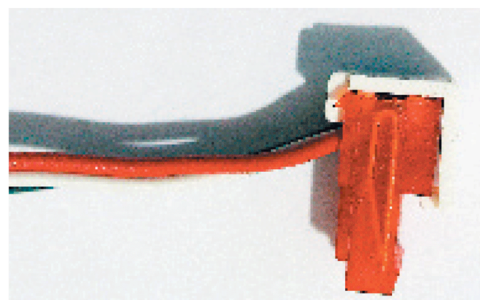
VCC CONNECTOR



http://www.vcclite.com/spec_pages/page18.htm

CNX-DF2604

AMP CONNECTOR



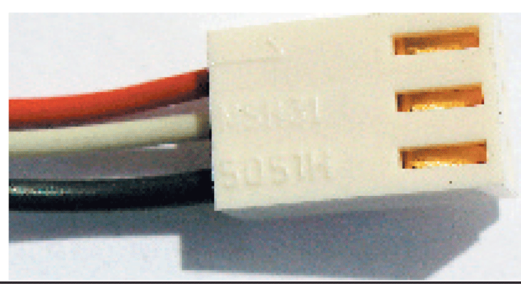
http://catalog.tycoelectronics.com/TE/bin/TE.Connect?C=1&M=BYPN&PID=223115&PN=3-640440-3&I=13

640440-3 Connector

643075-3 Strain Cover

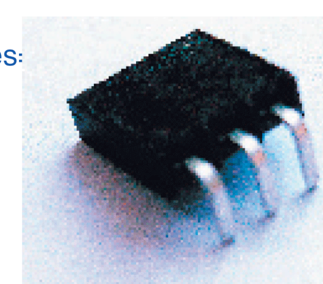
MOLEX CONNECTOR

http://www.molex.com/cgi-bin/bv/molex/jsp/products/datasheet.jsp?part=active/0760155405_BACKPLANE_CONNECTO.xml&BV_SessionID=@@@@1352563819.1189722437@@@@&BV_EngineID=cccdaddlmghmijhcflgcehedffgdfmk.0&channel=Products&Lang=english



Molex 5045-04/AG

SAMTEC CONNECTOR



http://www.samtec.com/technical_specifications/overview.aspx?series=

SSW-1-03-02-T-S-RA