L31S Series

Application Manual

█ Overview

The L31S series comprises open-loop and through-type current sensors.
The rated current varies from 50A to 600A.
As a Vref terminal is equipped, the reference voltage can be changed by connecting the Vref terminal to the reference voltage of the control circuit. (The reference voltage is the standard value of the sensor output voltage (Vout terminal) when the current to be measured is 0A.)

█ Characteristics

- Through-type supply system of the current to be measured.
- Open-loop-type circuit configuration.
- Connector-type input and output can be attached directly to a panel or to a bus bar.
- Vref terminal available.
- Because a ferrite core is used, the core loss is small.
- Simple structure

█ Uses

- General-purpose inverter
- Motor drive
- Generator

■ Format

L31S □□□ S 05 FS □

- □ — Connector specifications (see Table 1)
  - No mark: Sn plating
  - –A: Gold plating
- FS — Specification symbol
- 05 — Power-supply voltage 05: 5V
- S — Power-supply type S: Single power supply
- □□□ — Rated current value 050: 50A
  - 100: 100A
  - 200: 200A
  - 300: 300A
  - 400: 400A
  - 500: 500A
  - 600: 600A
- L31S — Series name L31S

Table 1: L31S series Specifications of connector and terminal plating

Model number		Connecter specifications		
		Connecter manufacturer	Connector product number /(Old product number)	Connector terminal Plating specification
L31S□□□S05FS	Standard	Molex	22-04-1041 / (5045-04A)	Sn
L31S□□□S05FS-A	Build-to-order manufacturing	Molex	22-11-1041 / (5045-04AG)	Gold

■Block diagram (+5V Single power-supply type)

L31S□□□S05FS

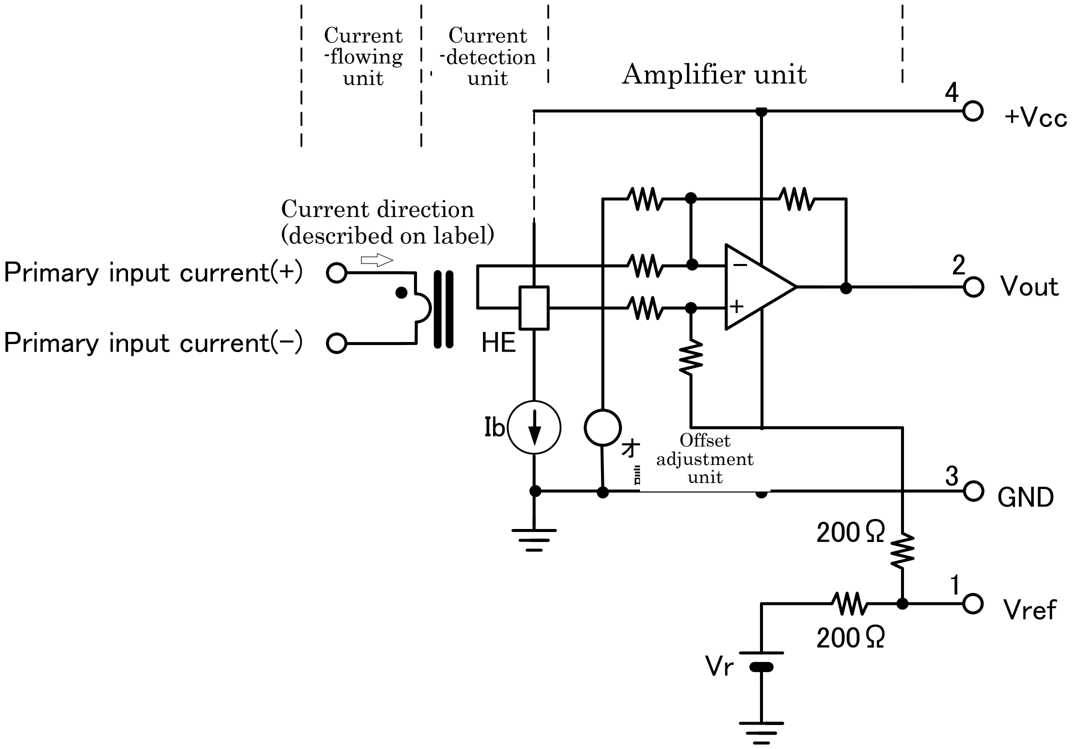


Fig. 1: L31S series　　Internal block diagram

Table 1: L31S□□□S05FS　　Description of terminal

Terminal number	Terminal name	Description	Remarks
1	Vref	Reference voltage terminal, 2.495Vtyp when open. Reference voltage can be changed by applying an external voltage in the range of 1.5V to 2.8V to the terminal.	
2	Vout	Output terminal Outputs the voltage converted from the measured current with reference to the voltage of the Vref terminal (1).	
3	GND	GND terminal	*
4	Vcc	Power-supply terminal. Apply +5V	
	Primary current (+)	The plus side of the primary current (measured current). When the primary current flows in the direction of the arrow (⇒) on the label, the	Through-hole

		output voltage is output with positive polarity to the output terminal (2).	
	Primary current (–)	The minus side of the primary current (measured current).	Through-hole

* The standard value of output voltage is

$$Vout = G \times I + Vof$$

; $G \equiv \frac{0.625V}{If}$ If : Rated current $Vof = Vref$ Terminal voltage $= 2.495V$ (when terminal 1 is open)

L31S Operation explanation

Current-detection unit

The current to be measured (primary input current) passes through the through-hole. The generated magnetic flux is focused by the core and applied to the magnetic-detection element (Hall element, HE).

The generated magnetic flux is proportional to the measured current I. The magnetic-detection element outputs a voltage proportional to the magnetic flux, i.e., provides an output voltage proportional to the current to the next-stage amplifier.

The current detector produces output up to the limit fixed by the rated current without saturation (refer to each catalog value). However, the linearity is guaranteed only up to the rated current value.

Amplifier unit

This block amplifies the output voltage of the magnetic-detection element. The amplifier unit outputs the voltage converted from the measured current with respect to the reference voltage Vref (1). The reference voltage is the output voltage when the current to be measured is 0A and is the same as the offset voltage. When the Vref terminal (1) is open, the standard reference voltage is 2.495V.

Because the output voltage of the magnetic-detection element is determined by factors such as the rated current, etc., the gain of the amplifier in each product is precisely adjusted in the factory.

Offset adjustment unit

The offset voltage serves as a reference of the output voltage and is the output voltage when the current to be measured is 0A. Possible deviation in the plus or minus direction owing to the initial deviation and temperature variations should be considered. (Please refer to the specifications table)

The main origin of the deviation of the offset voltage from the standard value lies in the fact that the Hall element HE, which is a magnetic-detection element, has an offset voltage. The offset voltage of the Hall element refers to the voltage output from the Hall element, which is minute but nonzero even in the absence of applied magnetic flux. A certain deviation of the offset voltage can arise in the amplifier unit instead of the Hall element. The offset adjustment unit has already been controlled in the factory in such a way that these offsets are globally canceled and fall within a predetermined deviation.

Current-flowing unit

The current-flowing part is used by passing a bus bar or electric wire through the through-hole in the main body. The current to be measured is supplied to the bus bar or the electric wire passing through the through-hole. The bus bar or electric wire generates heat owing to its own resistance component (copper loss). Choose either a bus bar or an electric wire such a way that the temperature of the sensor does not exceed the specified value even when the ambient temperature is the maximum allowable value.

In addition to the copper loss caused by the penetrated bus bar and electric wire, heat is generated owing to iron loss (core loss) of the core built into the sensor. Each loss varies depending on conditions such as the magnitude, frequency, and waveform of the current to be measured. The loss increases with the effective current or with the dominant frequency component of the current to be measured. When the current contains high-frequency components other than those of the fundamental wave, iron loss further increases. Therefore, confirmation using an actual current is necessary.

■Standard circuit 1

L31S□□□S05FS

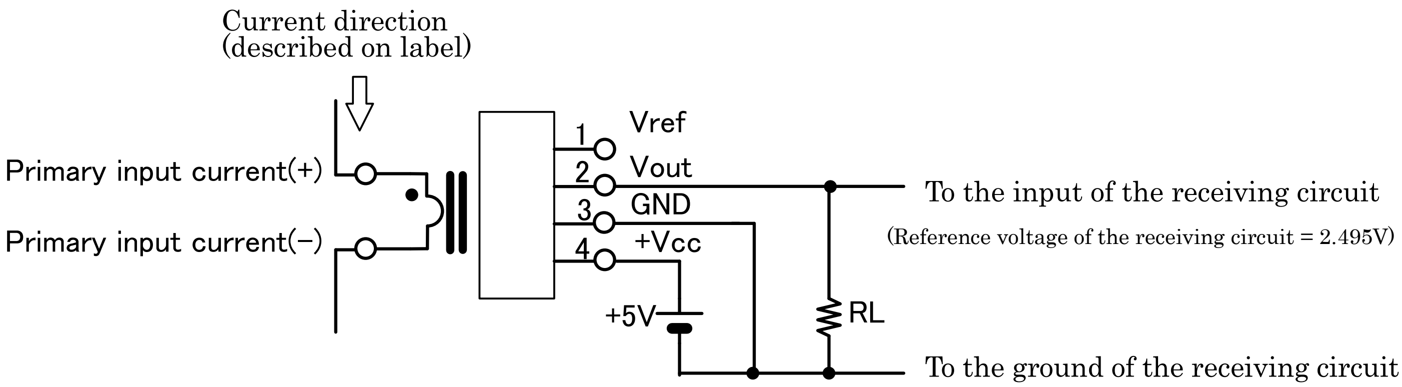


Fig. 2: L31S　　Standard circuit (when using built-in voltage Vref)

□Description of Fig. 2

Basic operation

This current sensor converts a measured current into a voltage. The output voltage Vout (2) in Fig. 2 is output in accordance with the potential (2.495Vtyp) of the Vref terminal (1). When the current to be measured is 0, Vout (2) = 2.495Vtyp. When the current to be measured is in the plus direction (direction ⇒ of the label), Vout (2) becomes 2.495 Vtyp + (voltage converted from the measured current). When the current to be measured is in the minus direction (direction opposite to ⇒ of the label), Vout (2) becomes 2.495Vtyp – (voltage converted from the measured current).

The standard value of the output voltage $Vout$ corresponding to the current Iin to be measured is expressed by the following equation.

$$Vout = G \times Iin + Vof$$

; $G \equiv \frac{0.625V}{If}$ If :Rated current Vof :Offset voltage Standard value is $2.495V$

RL = 10 kΩ in Fig. 2 is the equivalent resistance of the receiving circuit of the current sensor output Vout (2). The load resistance between the Vout terminal (2) and the GND potential (3) is standard 10 kΩ.

Effect of offset voltage

The offset voltage Vof is 2.495V ± 25mV at maximum in the case of L31S under the condition of Ta = 25°C. An error within ±4.0% occurs when measuring the rated current. When measured current is three times the rated current, the influence of the offset voltage decreases to 1/3 and the error is compressed to within ±1.34%. On the other hand, when the measured current is half the rated current, the error of the offset voltage ±25mV is within ±8% because the output voltage is 0.3125V.

In order to minimize the error, it is necessary to select a sensor with a rated current suitable for the measured current.

If a sensor with a higher rated current than necessary is selected, the measurement error due to the offset voltage increases. In selecting the rated current, it is necessary to consider the capability of covering the peak value of the measured current, heat generated by the bus bar, and the core built in the sensor, etc. as well as the above conditions.

Vref terminal

When voltage Vr (= 2.495Vtyp) built into the sensor is used as a reference, the Vref terminal (1) should be left open. As shown in Fig. 1, the protection resistor of 200 Ω typ is inserted between the built-in voltage Vr and the Vref terminal (1). When a circuit such as a resistor is connected to the Vref terminal (1), a voltage drop due to protection resistor occurs and an error can occur in the voltage of the Vref terminal (1) with respect to 2.495Vtyp.

When using an external voltage as the reference voltage, refer to standard circuit 2.

■ Standard circuit 2

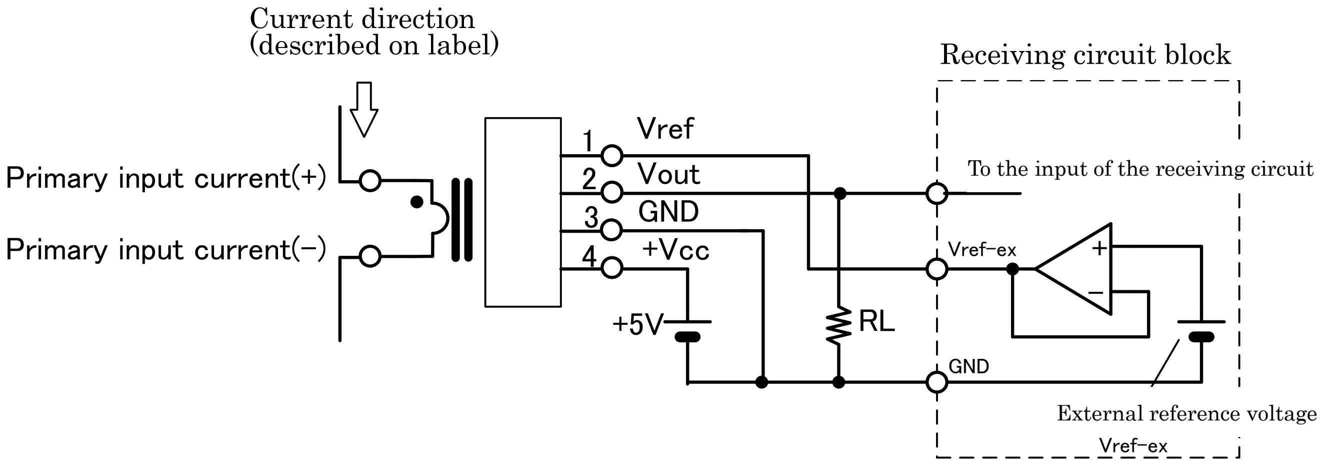


Fig. 3: L31S   Standard circuit (when using external Vref-ex voltage)

□Description of Fig. 3

Basic operation

The basic operation and the effect of offset voltage are the same as in Fig. 2. Note that the range of the current to be measured varies with the voltage selected for Vref-ex. (See graph 1)

Vref terminal

By connecting the external reference voltage Vref-ex to Vref terminal (1), the reference voltage value of the sensor output falls between Vref-ex and 2.495Vtyp. The value of Vref-ex must be within the range of 1.5V to 2.8V. Because the inflow and outflow currents from Vref terminal (1) increase up to 5mA, the reference power supply of Vref-ex must have the capabilities of a current sink and a source of ±5mA.

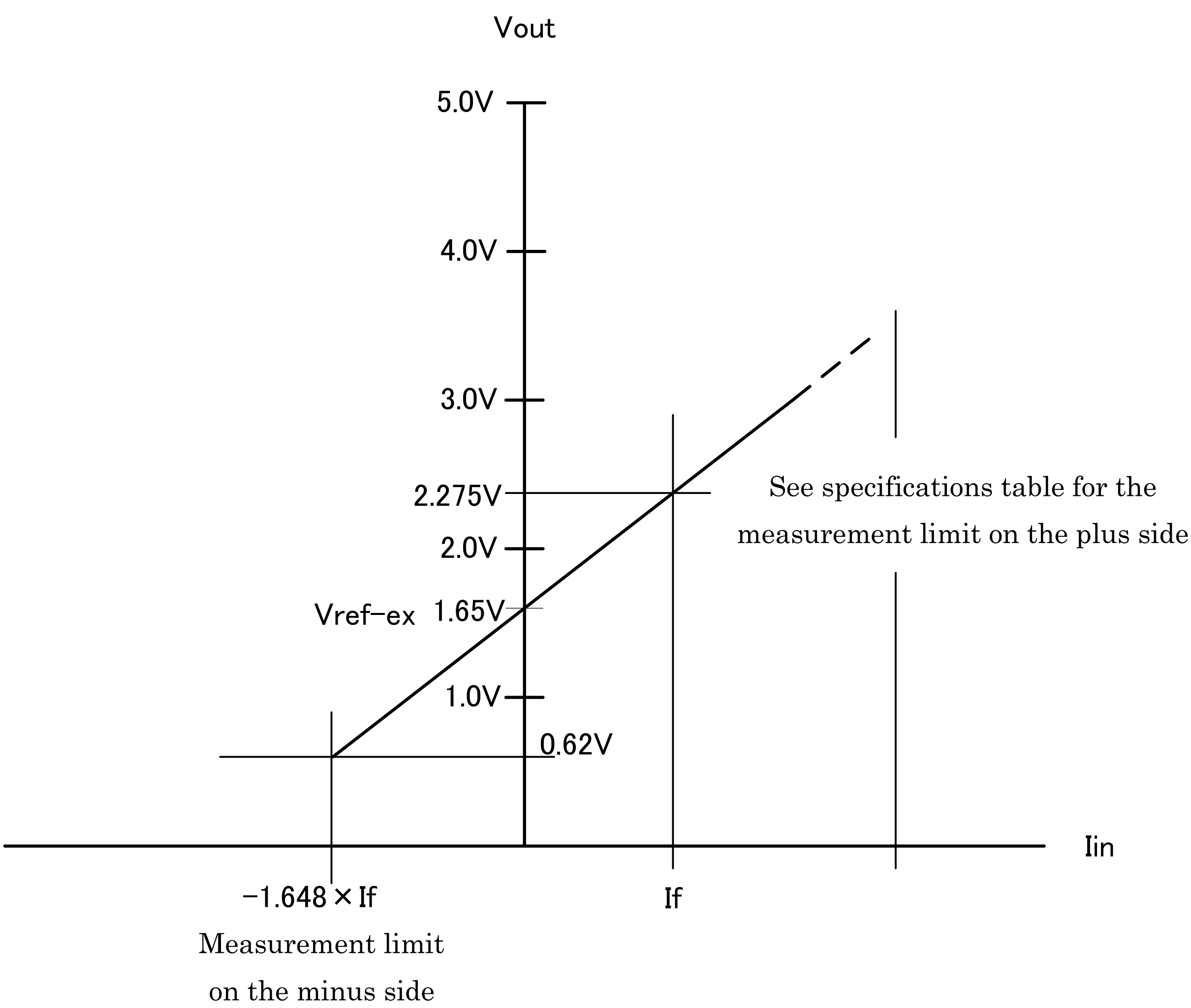
For example, when Vref-ex = 1.65V, the voltage of the output terminal Vout (2) becomes 1.65Vtyp when the primary current is 0A. In this case, the relationship between the primary current and the standard value of the output voltage Vout (2) is as follows.

$$Vout = G \times Iin + Vof$$

$$;\ G \equiv \frac{0.625V}{If} \qquad If : \text{Rated current} \ \ V o \neq 1.65V$$

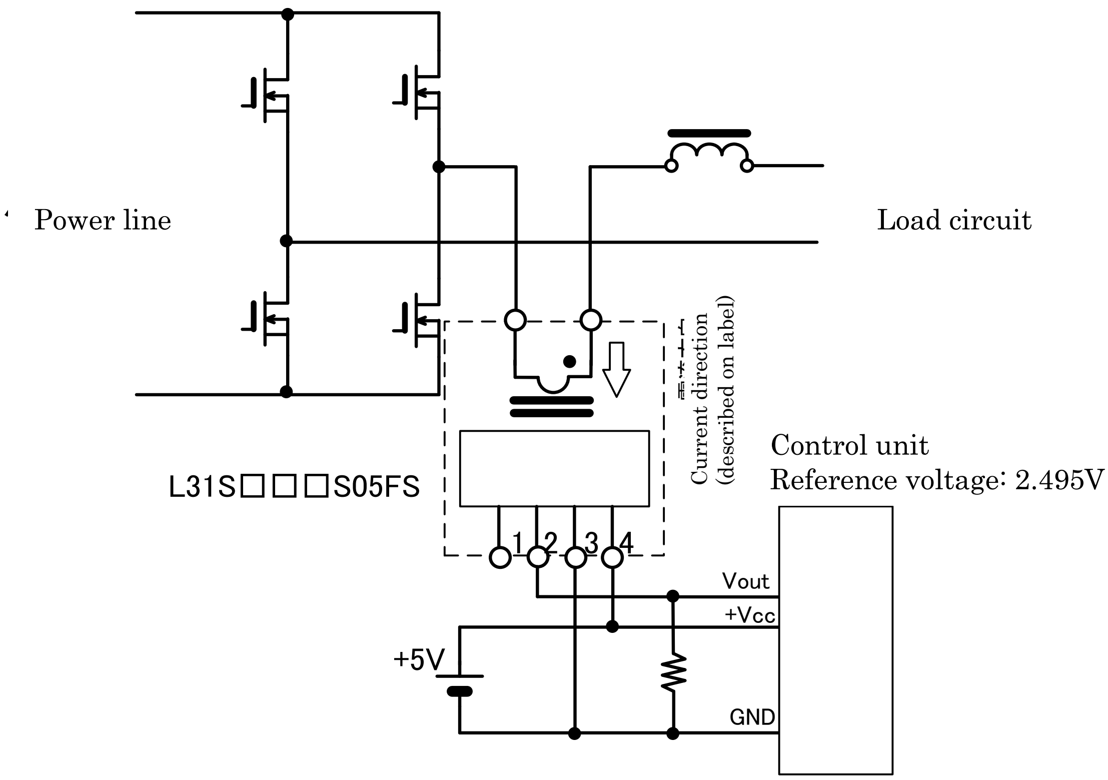
The reference voltage can be changed by connecting Vref terminal (1) to the reference voltage of the receiving circuit. In this case, as shown in Graph 1, the measurable range on the minus side of the measured current becomes narrower.

Graph 1


Vout
5.0V
4.0V
3.0V
2.275V
2.0V
Vref−ex
1.65V
1.0V
0.62V
Iin
−1.648×If
If
See specifications table for the
measurement limit on the plus side
Measurement limit
on the minus side

■ Application circuit: Inverter current-detection circuit

L31S□□□S05FS



The standard value of the output voltage $Vout$ corresponding to the current Iin to be measured is expressed by the following equation.

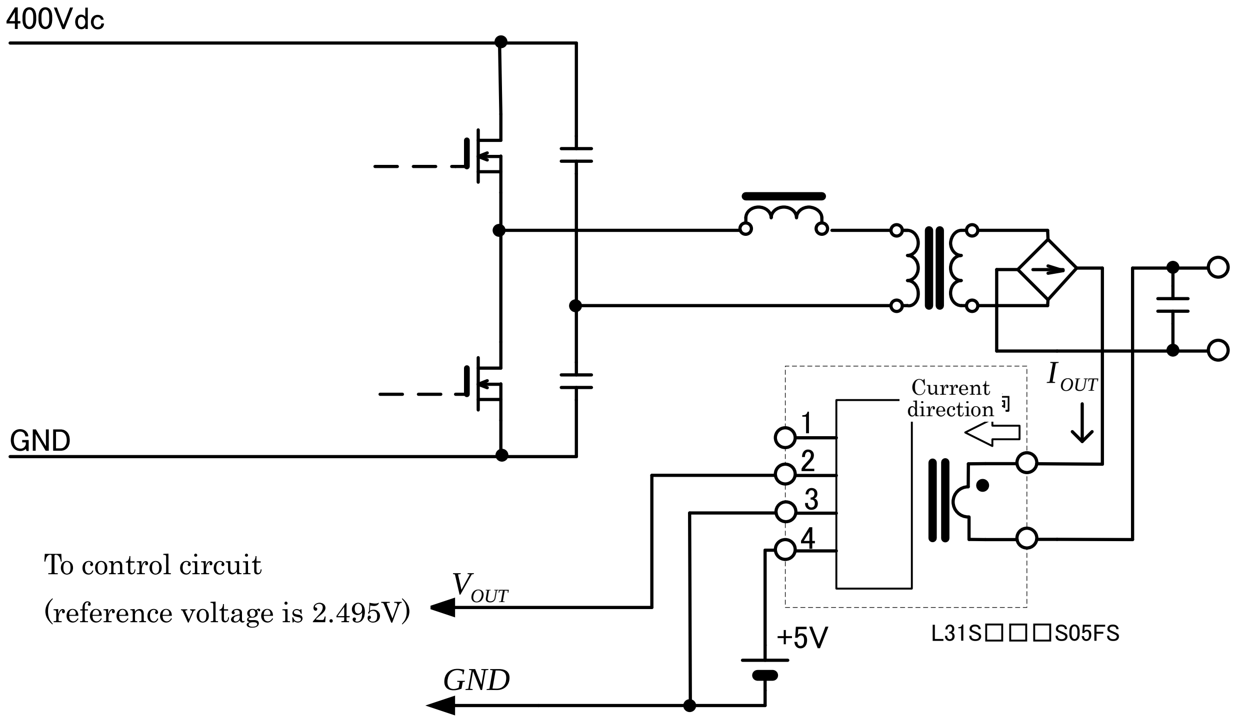
$$Vout = G \times Iin + Vof \quad \text{(Standard value)}$$

$$; \ G \equiv \frac{0.625V}{If} \qquad If: \text{Rated current} \quad Vof = 2.495Vtyp$$

Fig. 4: Inverter current-detection circuit

■ Application circuit: Overcurrent-detection circuit

L31S□□□S05FS



The standard value of the output voltage $Vout$ corresponding to the current $Iout$ to be measured is expressed by the following equation.

$Vout = G \times Iin + Vof$ (Standard value)

; $G \equiv \frac{0.625V}{If}$ If : Rated current $Vof = 2.495Vtyp$ (Offset voltage)

Fig. 5: Overcurrent-detection circuit