SYCT-3

250A High Accuracy Galvanically Isolated Hall Current Sensor IC

General Description

The SYCT-3 is a family of high accuracy galvanically isolated Hall-effect current sensor ICs for ±50 to ±250A. Current sensing supports both unidirectional and bidirectional, DC and AC currents. Applied current generates a magnetic field, then converted by into a proportional analog voltage. The bandwidth is up to 170kHz and the response time is 3µs.

A precise, proportional output voltage is provided by the high accuracy, good linearity, low temperature drift Hall IC, which is programmed for accuracy at the factory.

The package offers four options, PFF/PSF/PSS/SMT, for easy implementation, which the PFF is the standard package.

The SYCT-3 is suitable for insulation, small size with low heat generation applications, including automotive, industrial, and communications systems.

Features

- 3.3V single supply
- Wide Hall current sensing range:
  - Bidirectional: ±50 ~ ±250A
  - Unidirectional: 50 ~ 250A
- 170kHz typical bandwidth, response time 0.7µs
- UL60950-1(ed.2) certified
  - Dielectric Strength Test Voltage =4800V_{RMS}
  - Working Voltage for Basic Isolation=700V_{RMS}
  - Working Voltage for Reinforced Isolation = 450V_{RMS}
- Ultralow primary conductor resistance for power loss
- Factory-trimmed for high accuracy
- Package: PFF/PSF/PSS/SMT

Applications

- EV/HEV charger and DC-DC power supply
- Photovoltaic inverter power supply and UPS
- Motor control and frequency converter
- Communication and server power supply

Typical Application

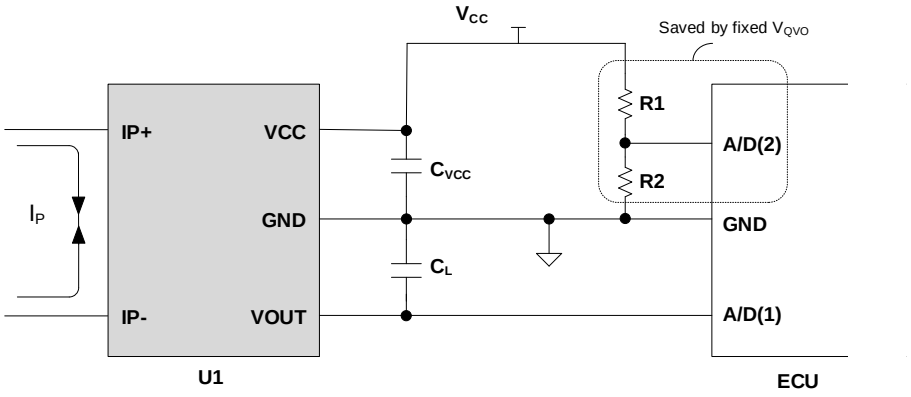

Figure 1. Typical Application Circuit

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Package Type

PFF
(Standard)

PSF

PSS

SMT

Ordering Information

Please indicate the package type in the suffix when ordering, such as SYCT050BR-3PSF.
If the packaging type is not specified, the default is to the standard (PFF) package.

Part Number	Architecture	I_P(A)	Sensitivity(mV/A)	V_{QVO}(V)	T_A(℃)
SYCT050BR-3	Bidirectional	±50	26.4	Vcc/2	-40 to 125
SYCT050BF-3	Bidirectional	±50	26.4	1.65	-40 to 125
SYCT050UF-3	Unidirectional	50	49.4	0.5	-40 to 125
SYCT100BR-3	Bidirectional	±100	13.2	Vcc/2	-40 to 125
SYCT100BF-3	Bidirectional	±100	13.2	1.65	-40 to 125
SYCT100UF-3	Unidirectional	100	24.7	0.5	-40 to 125
SYCT150BR-3	Bidirectional	±150	8.8	Vcc/2	-40 to 105
SYCT150BF-3	Bidirectional	±150	8.8	1.65	-40 to 105
SYCT150UF-3	Unidirectional	150	16.5	0.5	-40 to 105
SYCT200BR-3	Bidirectional	±200	6.6	Vcc/2	-40 to 85
SYCT200BF-3	Bidirectional	±200	6.6	1.65	-40 to 85
SYCT200UF-3	Unidirectional	200	12.4	0.5	-40 to 85
SYCT250BR-3	Bidirectional	±250	5.3	Vcc/2	-40 to 85
SYCT250BF-3	Bidirectional	±250	5.3	1.65	-40 to 85
SYCT250UF-3	Unidirectional	250	9.9	0.5	-40 to 85

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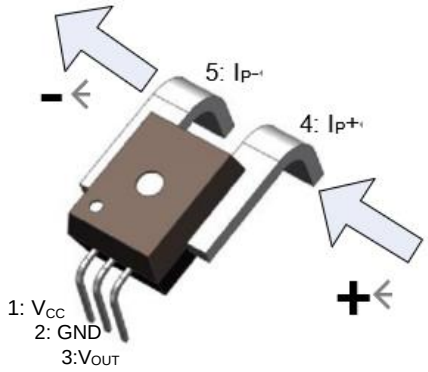
Pinout (Top View)



Pin Number	Pin Name	Pin Description
1	VCC	Power supply pin.
2	GND	Ground pin.
3	VOUT	Analog output pin.
4	IP+	Positive terminals for sensing current.
5	IP-	Negative terminals for sensing current.

Absolute Maximum Ratings (Note 1)

Supply Input Voltage ---------- -0.3 to 4.6V

Supply Input Current ---------- 18mA

Output Voltage ---------- 0.15 to V_{CC}-0.15V

Output Current (Note 2) ---------- ±40 mA

Ambient Temperature Range ---------- -40 to 125°C

Maximum Junction Temperature ---------- 165°C

Storage Temperature Range ---------- -55 to 150°C

Recommended Operating Conditions (Note 3)

Supply Input Voltage ---------- 3.0 to 3.6V

Isolation Characteristics

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test Voltage (Note 4)	V_{ISO}	Agency type-tested for 60 seconds per UL standard 60950-1 (edition 2)	4800	V_{RMS}
Working Voltage for Basic Isolation	V_{WVBI}	For basic (single) isolation per UL standard 60950-1 (edition 2)	990	V_{PK}
			700	V_{RMS}
Working Voltage for Reinforced Isolation	V_{WVRI}	For reinforced (double) isolation per UL standard 60950-1 (edition 2)	636	V_{PK}
			450	V_{RMS}

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Electrical Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 125°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Supply Voltage	V_{CC}	SYCT-xxxR-3	3.0	3.3	3.6	V
		SYCT-xxxF-3	3.14	3.3	3.46	
Supply Current	I_{CC}	$R_L \geq 10k\Omega$		13	18	mA
Power on Delay Time	T_{POD}	T_A=25°C		80		μs
Zero Current Output Voltage (Note 5)	V_{QVO}	SYCT-3xxxBR, T_A = 25°C		V_{CC}/2		V
		SYCT-3xxxBF, T_A = 25°C		1.65		V
		SYCT-3xxxUF, T_A = 25°C		0.50		V
Output Voltage Range @I_P	V_{OUT}-V_{QVO}	SYCT-3xxxBR, T_A = 25°C		±1.32		V
		SYCT-3xxxBF, T_A = 25°C		±1.32		V
		SYCT-3xxxUF, T_A = 25°C		2.47		V
Zero Current Output Ratiometry Error	E_{RAT}		-0.3		0.3	%
Output Load Resistance	R_L	V_{OUT} to V_{CC} or GND	10			kΩ
Output Load Capacitance	C_L	V_{OUT} to GND	6		100	nF
Response Time	t_{RES}	T_A=25°C, C_L=1nF		3		μs
Bandwidth	BW	Small signal –3dB, C_L=1nF, T_A=25°C	120	170		kHz
DC Output Impedance	R_{OUT}	T_A = 25°C		8		Ω

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: Maximum survivable sink or source current on the VOUT pin.

Note 3: The device is not guaranteed to function outside its operating conditions.

Note 4: 60-second test is only for UL test; Tested in production against UL60950-1 2nd Edition.

Note 5: The current sensing ranges (050/100/150/200/250) are represented by xxx.

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SYCT050BR-3 and SYCT050BF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 125°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-50		50	A
Sensitivity	Sens			26.4		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 50A		160	320	mA
Offset Current	I_{OE}	T_A = 25°C			0.3	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 125°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

SYCT050UF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 125°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		50	A
Sensitivity	Sens			49.4		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 50A		100	200	mA
Offset Current	I_{OE}	T_A = 25°C			0.15	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 125°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

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SYCT100BR-3 and SYCT100BF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 125°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-100		100	A
Sensitivity	Sens			13.2		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 100A		200	300	mA
Offset Current	I_{OE}	T_A = 25°C			0.5	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 125°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

SYCT100UF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 125°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		100	A
Sensitivity	Sens			24.7		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 100A		100	150	mA
Offset Current	I_{OE}	T_A = 25°C			0.25	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 125°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

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SYCT150BR-3 and SYCT150BF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 105°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-150		150	A
Sensitivity	Sens			8.8		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 150A		300	400	mA
Offset Current	I_{OE}	T_A = 25°C			0.75	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 105°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

SYCT150UF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 105°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		150	A
Sensitivity	Sens			16.5		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 150A		180	240	mA
Offset Current	I_{OE}	T_A = 25°C			0.45	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 105°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

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SYCT200BR-3 and SYCT200BF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 85°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-200		200	A
Sensitivity	Sens			6.6		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 200A		400	500	mA
Offset Current	I_{OE}	T_A = 25°C			1	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 85°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

SYCT200UF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 85°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		200	A
Sensitivity	Sens			12.4		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 200A		200	250	mA
Offset Current	I_{OE}	T_A = 25°C			0.5	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 85°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

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SYCT250BR-3 and SYCT250BF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 85°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-250		250	A
Sensitivity	Sens			5.3		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 250A		500	640	mA
Offset Current	I_{OE}	T_A = 25°C			1.25	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 85°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

SYCT250UF-3 Performance Characteristics

(V_{CC} = 3.3V, C_{VCC} = 0.1μF, T_A = -40 to 85°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		250	A
Sensitivity	Sens			9.9		mV/A
Accuracy Performance						
Sensitivity Error	E_{SENS}	T_A=25°C	-1		1	%
Voltage Offset Error	V_{OE}	I_P=0A, T_A = 25°C	-4	±3	4	mV
		I_P=0A	-20	±8	20	mV
Magnetic Offset Error	I_{OM}	I_P=0A, T_A = 25°C, after excursion of 250A		250	320	mA
Offset Current	I_{OE}	T_A = 25°C			0.65	A
Linearity Error	E_{LIN}	Full scale of I_P	-1	0.5	1	%
Total Output Error	$E_{TOT, H}$	Full scale of I_P, T_A = 25 to 85°C	-2		2	%
	$E_{TOT, L}$	Full scale of I_P, T_A = –40 to 25°C	-2		2	%

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Operation

The SYCT-3 is a family of high accuracy galvanically isolated current sensor ICs. There are various output modes for measuring bidirectional or unidirectional current from 50A to 250A, which output the analog voltage proportional to the AC or DC current. The bandwidth is up to 170kHz.

A precise, proportional output voltage is achieved by the high accuracy Hall IC, which is trimmed for accuracy at the factory.

The package offers four options, PFF/PSF/PSS/SMT, for easy implementation, which the PFF is the standard package.

Application Information

Sensitivity (Sens)

Sensitivity is the slope of the approximate straight line between the output voltage (V_{OUT}) and the input primary current (I_P) within the sensing range. V_{QVO} is the quiescent voltage output.

$$V_{OUT} = V_{QVO} + Sens \times I_P$$

Sensitivity Error (E_{SENS})

The sensitivity error (E_{SENS}) is the percent difference between the measured sensitivity ($Sens_M$) and the ideal value ($Sens_{TYP}$).

$$E_{SENS} = \frac{Sens_M - Sens_{TYP}}{Sens_{TYP}} \times 100\ (\%)$$

Response Time (t_{RES})

Response time (t_{RES}) is defined as the time delay from the 90% of input primary current (I_P) to the 90% of the output voltage (V_{OUT}).

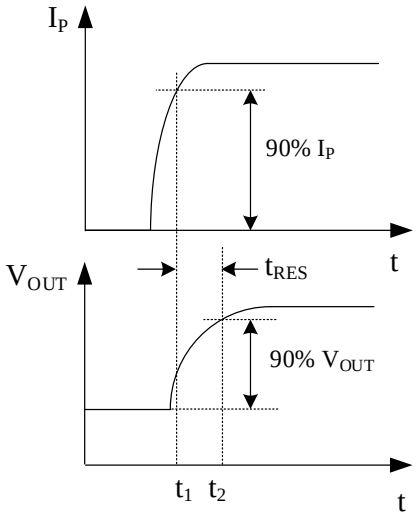

Figure 3. Response Time

Quiescent Voltage Output (V_{QVO})

The V_{QVO} is defined as the output voltage (V_{OUT}) when the primary current (I_P) is zero. It is related to V_{CC}, current direction, and internal logic. The relationship is shown as below, where xxx represents the sensing range (050/100/150/200/250):

Part Number	V_{QVO}
SYCTxxxBR-3	$V_{CC}/2$
SYCTxxxBF-3	1.65V
SYCTxxxUF-3	0.50V

Voltage Offset Error (V_{OE})

The voltage offset error (V_{OE}) is defined as the deviation of the zero current output voltage from its ideal quiescent value (V_{QVO}), due to nonmagnetic causes.

Zero Current Output Ratiometric Error (E_{RAT})

When the supply voltage V_{CC} changes from the typical value ($V_{CC,TYP}$) to $V_{CC,MIN} < V_{CC,M} < V_{CC,MAX}$ there will be a certain deviation between the measured zero current output ($V_{QVO,M}$) and its ideal value ($V_{QVO,TYP}$). The relationship is shown as below:

$$E_{RAT} = 1 - \frac{V_{QVO,M}}{V_{CC,M}} \times \frac{V_{CC,TYP}}{V_{QVO,TYP}}$$

Magnetic Offset Error (I_{OM})

The magnetic offset is due to the remnant field of the core material. The magnetic offset error is highest when the primary current approaches zero from the maximum value.

Linearity Error (E_{LIN})

The linearity error (E_{LIN}) is the maximum positive or negative error between the measured output voltage and the ideal value within the sensing range.

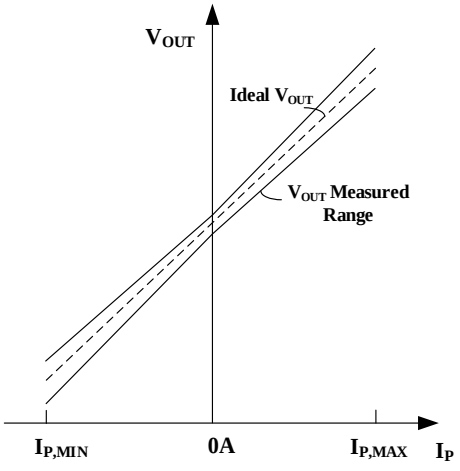

Figure 4. Linearity Error

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Total Output Error (E_{TOT})

Total output error (E_{TOT}) is defined as the difference between the ideal output voltage (V_{OUT}) and the actual output voltage ($V_{OUT, IP}$), divided by the ideal sensitivity (Sens), relative to the primary current (I_P) flowing through the primary conduction path:

$$E_{TOT} = \frac{V_{OUT,IP} - V_{OUT}}{Sens \times I_P}$$

At relatively high current, E_{TOT} will be mostly due to sensitivity errors; but at relatively low current, E_{TOT} will be mostly due to the voltage offset error (V_{OE}). As the primary current (I_P) approaches zero, the E_{TOT} approaches infinity due to the voltage offset error (V_{OE}).

Layout Design

The layout design of the SYCT-3 is relatively simple. For the best performance, the attention should be paid to heat dissipation and traces.

1. It is best practice for the current to approach the IC parallel to the current-carrying pins, and for the current-carrying trace to not creep towards the center of the package.

2. It is best to place C_{VCC} and C_L close to the IC to achieve better filtering performance.

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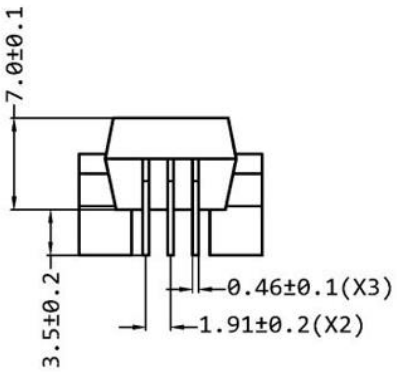
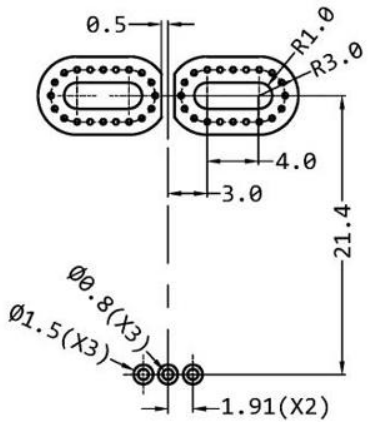
Package outline & PCB Layout Design

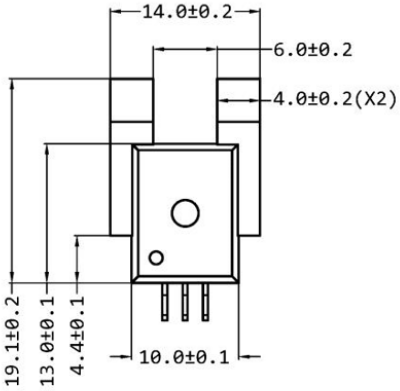
Standard (PFF) Package



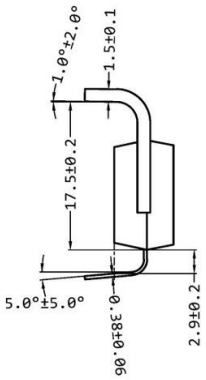
Side View



PCB layout design



Top View



Side View

Terminals	Definitions
1	Vcc
2	GND
3	Vout
4	IP+
5	IP-

Notes: **All dimensions are in millimeters.**
All dimensions don't include mold flash & metal burr.

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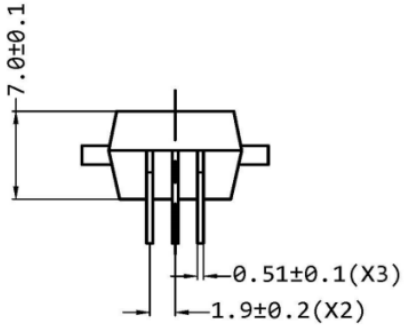
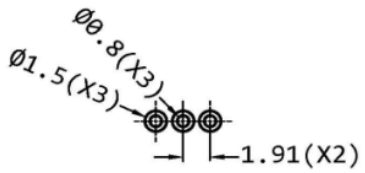
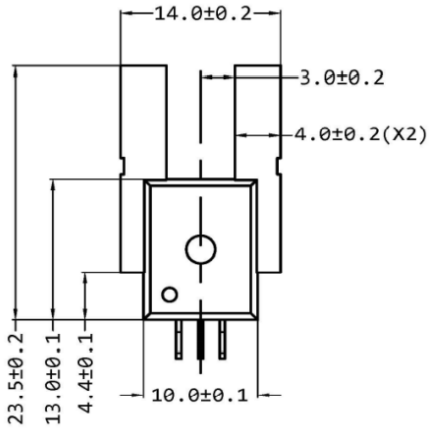
PSF Package



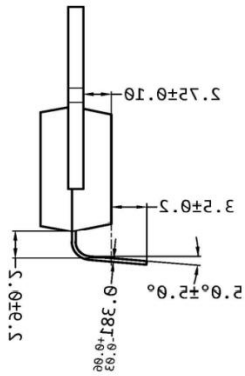
Side View



PCB layout design



Top View



Side View

Terminals	Definitions
1	Vcc
2	GND
3	Vout
4	IP+
5	IP−

Notes: **All dimensions are in millimeters.**
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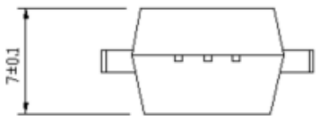
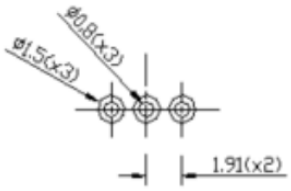
PSS Package



Side View



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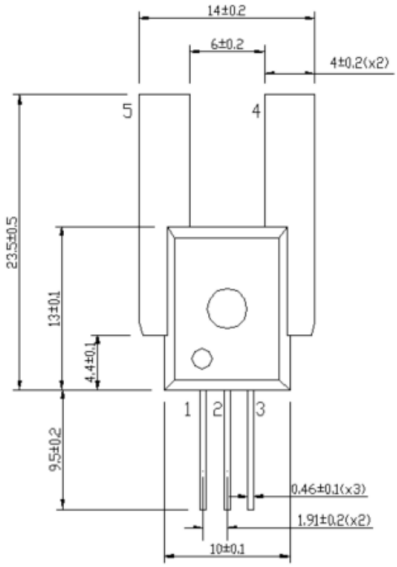
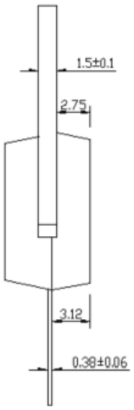


Top View



Side View

Terminals	Definitions
1	VCC
2	GND
3	VOUT
4	IP+
5	IP-

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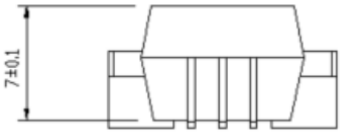
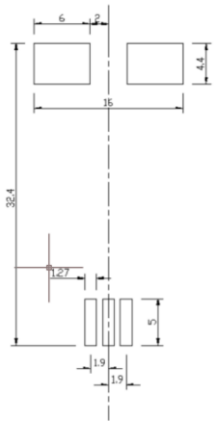
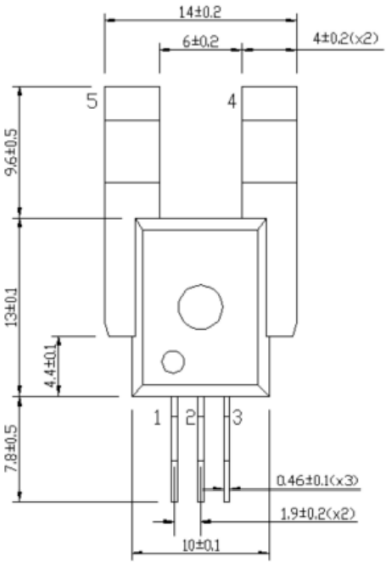
SMT Package



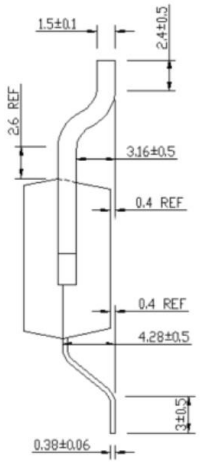
Side View



PCB layout design



Top View



Side View

Terminals	Definitions
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2	GND
3	VOUT
4	IP+
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