Data Sheet

Hall effect transducers, current and voltage

This data sheet covers the following products:

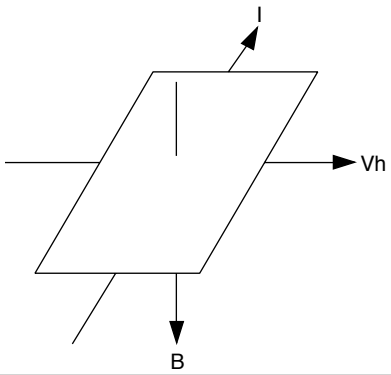
RS stock no.	Type of transducer
286-311	Multi-range current, PCB mounting
286-327 286-333	50/100A instantaneous, PCB mounting
286-349 286-355	50/100A true rms/instantaneous, PCB mounting
286-377 286-383 286-399 286-406 286-412 286-434	Instantaneous, split core
286-456 286-462 286-478 286-484 286-513	True rms, split core
257-414 257-420 257-436 256-174 256-180 256-196	Instantaneous, solid core
257-183 257-177 256-219 256-203	True rms, solid core
286-361	Voltage transducer, PCB mounting

Introduction

This range of transducers utilises Hall-effect technology, whereby current measurement is carried out by measuring the magnetic field that is generated by a current carrying conductor.

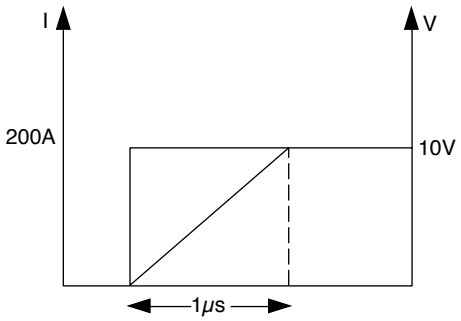
The field is measured by placing a thin constant-current carrying semiconductor at right angles to the magnetic field (B) (see Figure 1) this results in a voltage known as the Hall voltage (Vh) being seen across the semiconductor, that is linearly proportional to the magnetic field and hence the current (I) flowing in the circuit.

Figure 1 **Schematic representation of Hall effect principle**



This effect can be used to measure unidirectional, non-changing currents, as well as the complex waveform currents found in many electronic variable speed controllers. The sensors' output does not depend upon a changing magnetic field, only the strength of the field. The transducer responds almost instantaneously when the magnetic field changes (Figure 2).

Figure 2 **Simplified response of the transducer to a stepped current input (solid and split core products)**



The delay is given by the di/dt following which is better than 200A per μs ie. the transducers' output will take 1μs maximum to reach 10V for a step increase of 200A.

These transducers offer a flexible alternative to the shunt or current transformer for measuring ac or dc currents up to 400A peak. eg. In high current dc circuits a standard current shunt would consume a considerable amount of energy, whereas these current transducers have virtually no effect on the circuit loading.

Most versions supply an output that is linearly related to the current flowing through the centre core. The multi-range device (**RS** stock no. 286-311) requires the primary to be connected to it in order to generate a proportional output. The transducers are available in PCB mounting, split core (retro-fit option) and solid core configurations.

Operating considerations

1. Although the sensor is isolated from the current carrying conductor, preventing damage to the unit from overcurrent and high voltage transients care should be taken to ensure that the maximum eddy current power Pe is not exceeded. If Pe is exceeded, excess self heating of the flux core will occur, leading to physical damage. The eddy current power is related to both frequency and current.
   ie. $Pe \propto (I \times f)^2$

To prevent excess heating, the product $I_{RMS} \times f$ should not exceed 400,000.

The maximum operating frequencies and currents can now be calculated.

Examples:

a) To calculate the maximum frequency allowable with a current of 200A ac peak ($140A_{RMS}$)

$$I \times f = 400\,000$$

$$f = \frac{400\,000}{140} = 2857Hz$$

b) To calculate the maximum 20kHz ripple current that can be superimposed on a 150Adc current

$$I \times f = 400\,000$$

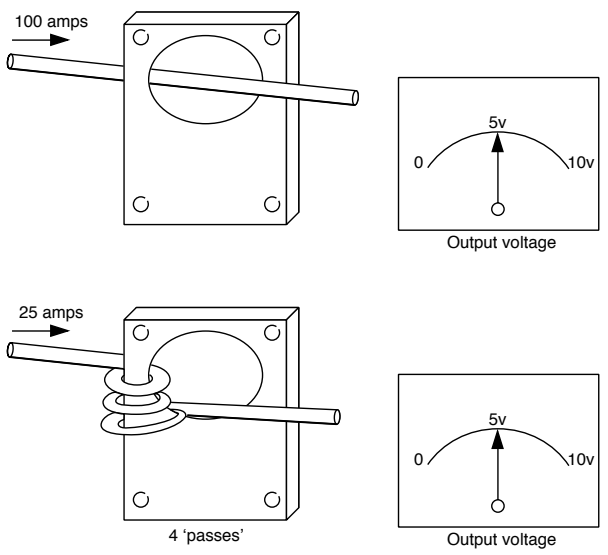
$$I = \frac{400\,000}{20\,000} = 20A$$

ie. a ± 10A ripple current

Note: A non-changing current produces no self heating within the core and does not therefore enter the calculations.

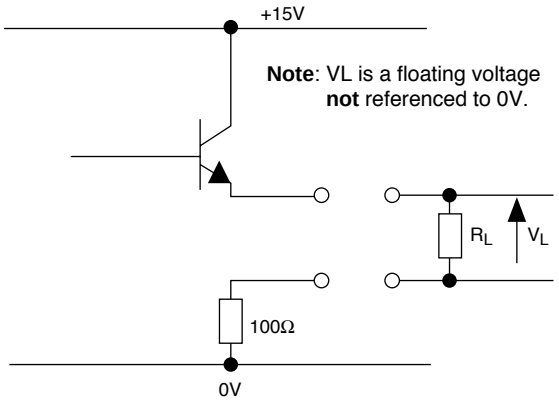
2. If the specified current range of a transducer is 0-200A it is possible to lower the current range for the same output voltage ie. increase the transducer's resolution. This may be done by increasing the number of times that the current carrying conductor passes through the centre of the core ie. 'multi-turning' (see Figure 3).

Figure 3 **'Multi-turning' (200A)**



3. Whereas the voltage output options have operational amplifiers as the final output stage, the 4-20mA options have an extra transistor stage at the output. A resistor R_L should be connected between the positive and negative load connections of the sensor. This sense resistor should not exceed 500Ω. In practice R_L has values of either 50Ω or 500Ω which gives 1V or 10V respectively for a 20mA current flow (see Figure 4).

Figure 4 **4-20mA output configuration**



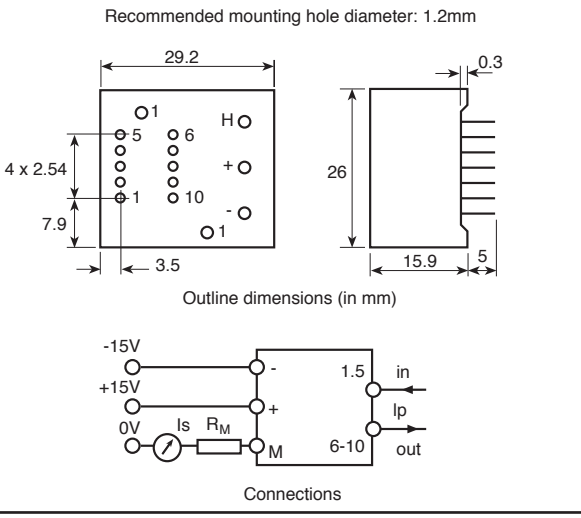
PCB mounting transducers

Two types of PCB mounting current transducers, based on the Hall effect, are available. The first of these is a multi-range transducer capable of up to 25A input. The second is a range of compact, low profile transducers.

Multi-range current transducer (**RS** stock no. 286-311)

By the use of a set of primary connection pins the range of nominal currents capable of being measured is 25/12/8/6/5A with an output of 25mA in each case to an accuracy of ±0.6%. The 25mA output can then be fed through a measuring resistor in series with the power supply zero to derive a voltage output.

The transducer requires a power supply of ±15V.



Principle of operation

The magnetic field produced by the primary ampere-turns (current to be measured × number of primary turns) is compensated by a magnetic field produced by the secondary ampere-turns (output current × number of secondary turns). The system incorporates an induction detector connected to an electronic circuit generating the output current.

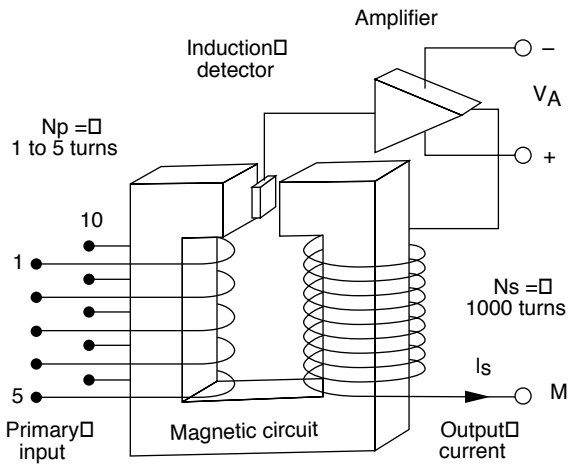
Thus the fundamental equation applies:

$$N_P \times I_P = N_S \times I_S$$

Electrical characteristics

Nominal currents	I	25/12/8/6/5At rms
Measuring range	I_P	0 to ±36At
Load resistance	R_M	min. 100Ω max. 190Ω
Maximum error at +25°C	e	$\pm 0.6\% I_N$
Nominal output current	I_S	25mA
Supply voltage	V_A	±15 (±5%)V
Turn ratio		1-2-3-4-5/1000
Dielectric strength		2.5kVrms/50Hz/1min

Figure 5 **Multi-range current transducer functional diagram**



Technical specification

Calibration accuracy at +25°C	0.6% of I_N
Nominal analogue output current	25mA
Turns ratio	1-2-3-4-5/1000
Supply voltage	±15V (±5%)
Isolation	2.5kVrms/50Hz/1 min
Linearity	<0.2%
Response time	>1µs
Bandwidth	dc to 150kHz (–1dB)
Operating temperature	0°C to +70°C
Storage temperature	–25°C to +85°C
Current consumption	10mA + output current
Secondary internal resistance	110Ω (at +70°C)
Weight	22g
Package	Potted in insulated self extinguishing plastic case

Polarity markings — A positive output current is obtained on terminal M when the primary current flows from terminals 1, 2, 3, 4, 5 to terminals 10, 9, 8, 7, 6

Connection to primary circuit — on 10 pins 1mm diameter

Connection to secondary circuit — On 3 pins 1mm diameter

Accuracy – dynamic performance

Parameter	Symbol	Conditions	Typical	Max.	Unit
Offset	I_{OS}	I_p = 0A, T = +25°C		±0.05	mA
Residual current*	I_{HC}	I_p = 0A, T = +25°C		±0.08	mA
Offset current drift with temperature	dI_{OS1}	I_p = 0A, T = 0°C to +25°C	±0.20	±0.30	mA
	dI_{OS2}	I_p = 0A, T = +25°C to +70°C	±0.25	±0.60	mA
Linearity	e_L	I_{OS} = 0mA		±0.2	% I_P
Delay time	td	I_p = 25A.t (see Figure 8)		1	µs
Bandwidth	f	I_p = 25 A. t at –1dB	dc to 150		kHz

*Result of the coercive field of the magnetic circuit

Figure 6 **Load resistance *vs* primary current (maximum and minimum values)**

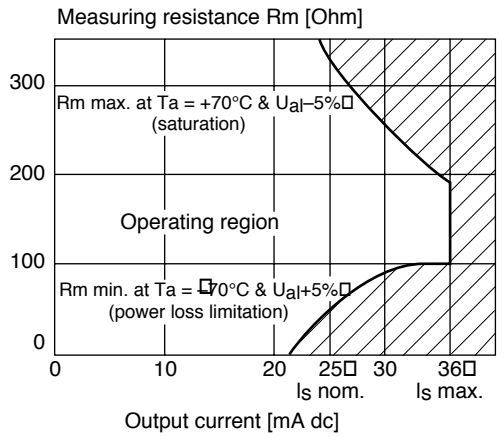


Figure 7 **Current derating *vs* frequency and ambient temperature**

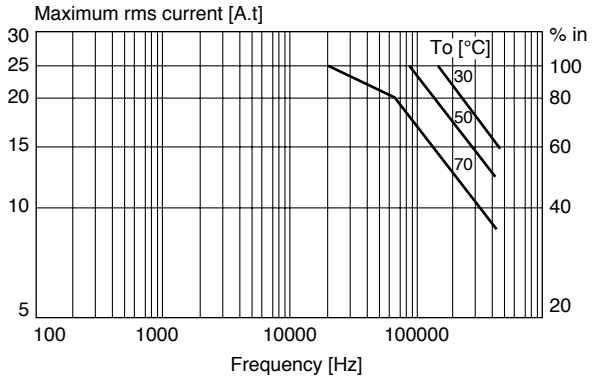


Figure 8 **Delay time between output current and primary current (di/dt response)**

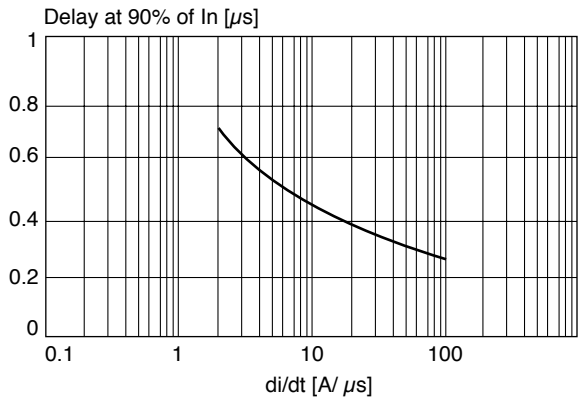
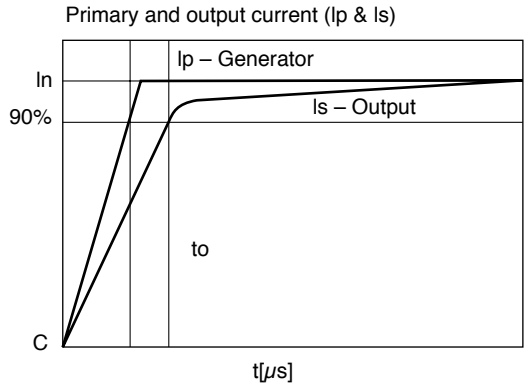
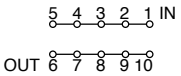
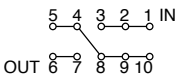
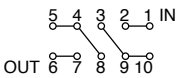
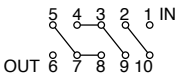
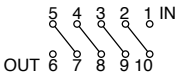


Figure 9 **Definition of delay time *vs* output current**

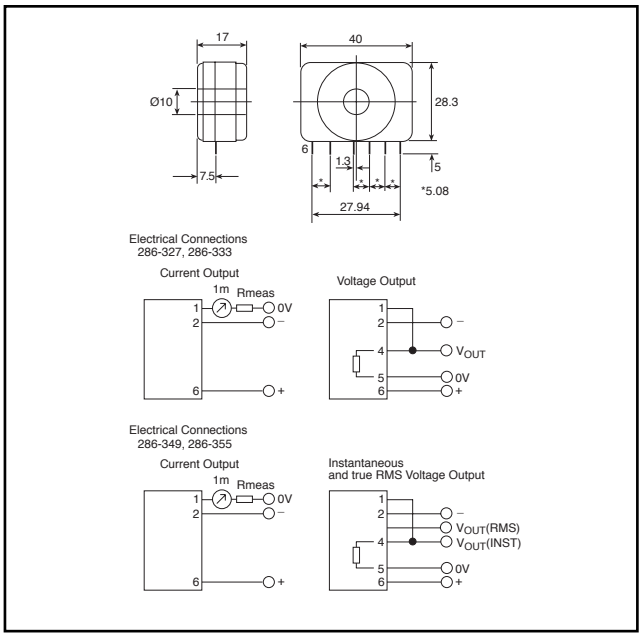


Connection table

Number of of primary turns	Primary current nominal I_N (A)	Primary current maximum I_P (A)	Nominal output current I_S (mA)	Turn ratio	Primary resistance (mOhm)	Primary insertion inductance (µH)	Recommended connections
1	25	36	25	1/1000	0.3	0.023	
2	12	18	24	2/1000	1.1	0.09	
3	8	12	24	3/1000	2.5	0.21	
4	6	9	24	4/1000	4.4	0.37	
5	5	7	25	5/1000	6.3	0.58	

Compact, low profile current transducers

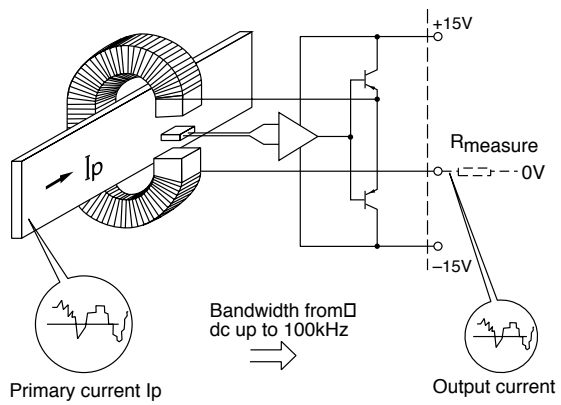
These are fast response PCB mountable current transducers employing the Hall effect principle to accurately measure ac, dc, or complex currents. The transducers use the feedback operating technique and have high accuracy analogue outputs. The primary current is sensed by passing the conductor through a 10mm diameter hole. An increase in sensitivity can be achieved when measuring lower currents than the nominal 50A or 100A by increasing the number of times the primary current conductor passes through the centre hole, ie. to measure 5A using **RS** stock no. 286-327, 10 passes of the cable can be arranged giving 50 ampere turns and a full output current or voltage signal is derived. See 'Operating conditions' for a further example.



Principle of operation (Figure 10)

The magnetic flux created by the primary current (I_p) is balanced through a secondary coil using a Hall device and associated electronic circuit. The secondary (compensating) current is an exact representation of the primary current.

Figure 10 **Compact, low profile current transducer functional diagram**



Technical specification

RS stock no.	286-327	286-333
Nominal current I_N	50A rms	100A rms
Output modes		
1. Current output	1mA/A	1mA/A
Measuring range	0 to ±160A (Supply voltage ±15V; Rmeas = 50Ω)	0 to ±160A (Supply voltage ±15V; Rmeas = 50Ω)
Overall accuracy at +25°C	±0.5% of I_N	±0.5% of I_N
2. Voltage output	100mV/A	50mV/A
Measuring range	0 to ±50A	0 to ±100A
Overall accuracy at +25°C	±1.0 of I_N	±1.0 of I_N
Turns ratio	1:1000	1:1000
Supply voltage	±15V (±5%)	±15V (±5%)
Dielectric strength	3kVrms/50Hz/1 min	3kVrms/50Hz/1 min

Dynamic performance

Zero drift (between 0°C and +70°C)	Max. ±0.6mA	Max. ±0.6mA
Linearity	±0.1% of I_N	±0.1% of I_N
Response time	<1 microsecond	<1 microsecond
di/dt accurately followed	<50A per microsecond	<50A per microsecond
Frequency range	dc to 100kHz	dc to 100kHz

General data

Operating temperature	0°C to +70°C	0°C to +70°C
Storage temperature	–25°C to +85°C	–25°C to +85°C
Current drain	15mA +Im (measuring current)	15mA +Im (measuring current)
Internal resistance (for current output)	25Ω	25Ω
Connections	On 6 pins 0.63 × 0.56mm	On 6 pins 0.63 × 0.56mm
Case material	Flame retardant Noryl Grade V0-150	Flame retardant Noryl Grade V0-150
Weight	15g	15g
Output provisions		
Current output	On Pin 1	On Pin 1
Voltage output	On Pin 4 (Pins 1 and 4 must be linked)	On Pin 4 (Pins 1 and 4 must be linked)

Technical specification

RS stock no.	286-349	286-355
Nominal current I_N	50A rms	100A rms
Output modes		
1. Current output (instantaneous)	1mA/A	1mA/A
Measuring range	0 to ±160A (Supply voltage ±15V; Rmeas = 50Ω)	0 to ±160A (Supply voltage ±15V; Rmeas = 50Ω)
Overall accuracy at 25°C	±0.5% of I_N	±0.5% of I_N
Linearity	±0.1% of I_N	±0.1% of I_N
Turns ratio	1:1000	1:1000
Internal resistance	25Ω	25Ω
Zero drift (between 0°C and +70°C)	Max. ±0.6mA	Max. ±0.6mA
Response time	<1µs	<1µs
di/dt accurately followed	>50A/µs	>50A/µs
Frequency range	dc to 100kHz	dc to 100kHz
2. Voltage output (instantaneous)	20mV/A	10mV/A
Measuring range	0 to ±50A	0 to ±100A
Overall accuracy at +25°C	±1% of I_N	±1% of I_N
Linearity	±0.1% of I_N	±0.1% of I_N
Zero drift (between 0°C and +70°C)	Max. ±12mV	Max. ±6mV
Response time	<1µs	<1µs
di/dt accurately followed	>50A/µs	>50A/µs
Frequency range	dc to 100kHz	dc to 100kHz
3. Voltage output (true rms)	20mV/A	10mV/A
Measuring range	±50A	±100A
Overall accuracy at +25°C	±1% of I_N	±1% of I_N
Linearity	±0.2% of I_N	±0.2% of I_N
Zero drift (between 0°C and +70°C)	Max. ±10mV	Max. ±10mV
Average time constant	100ms	100ms
Frequency range	40Hz to 100KHz	40Hz to 100KHz
Crest factor	3 for stated accuracy	3 for stated accuracy
Output resistance	<1Ω	<1Ω

General data

Operating temperature	0°C to +70°C	0°C to +70°C
Storage temperature	–25°C to +85°C	–25°C to +85°C
Current drain	15mA +1m (measuring current)	15mA +1m (measuring current)
Dielectric strength	3kVrms/50Hz/1 min	3kVrms/50Hz/1 min
Connections	On 6 pins 0.63 × 0.56mm	On 6 pins 0.63 × 0.56mm
Case material	Flame retardant Noryl Grade V0-150	Flame retardant Noryl Grade V0-150
Weight	20g	20g

Output provisions

Current output	On Pin 1	On Pin 1
Voltage output (instantaneous)	On Pin 4 (Pins 1 and 4 must be linked)	On Pin 4 (Pins 1 and 4 must be linked)
Voltage output (true rms)	On Pin 3 (Pins 1 and 4 must be linked)	On Pin 3 (Pins 1 and 4 must be linked)

Selection/Cross reference chart – PCB mounting current transducers

RS stock no.	Input (I_N)	Output	Output version	Manufacturer's reference
286-311	25A	25mA	Instantaneous	LA 25-NP
286-327	50A	50mA or 5V	Instantaneous	LTA 50-P/SP1
286-333	100A	100mA or 5V	Instantaneous	LTA 100-P/SP1
286-349	50A	1V T. rms and 5V inst.	True rms/ Instantaneous	LTA 50-PR
286-355	100A	1V T. rms and 5V inst.	True rms/ Instantaneous	LTA 100-PR

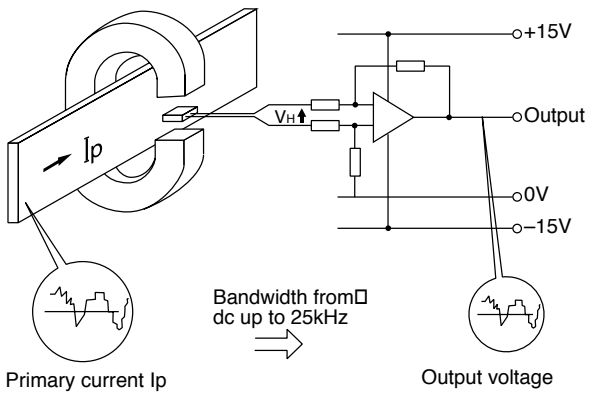
Split core/Solid core transducers

Two types of 'larger current' transducers, based on the Hall effect, are available. The first of these is a split core transducer which, due to its construction, enables the transducer to 'clamp' over the conductor being measured. This facility makes it particularly useful in retrofit applications. The second type is the standard 'solid core' intended for fitting during initial machine installation or planned maintenance when the conductor to be measured can be disconnected.

Principle of operation (Figure 11)

The magnetic flux created by the primary current (I_p) is concentrated in a magnetic circuit and measured using a Hall device. The output from the Hall device is then signal conditioned to provide an exact representation of the primary current.

Figure 11 **Split core/Solid core functional diagram**



Split core current transducers

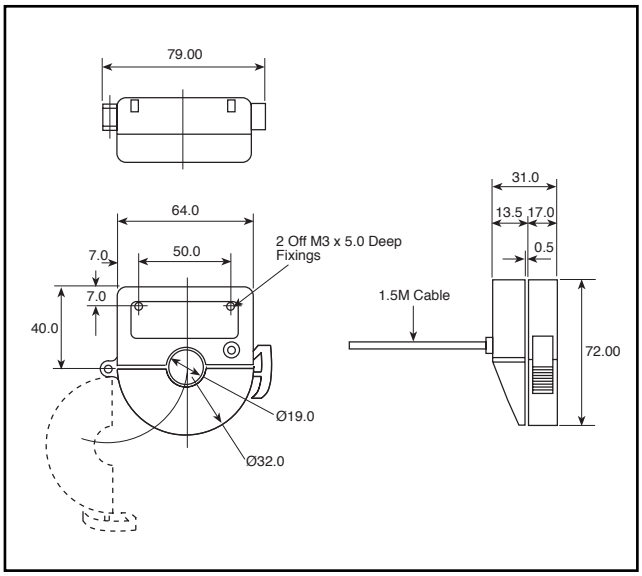
This range of split core current transducers employs Hall effect technology to enable measurements to take place of ac, dc and complex waveforms. Available in a range of primary current ratings from 200A to 500A with instantaneous or true rms output signal options available.

The split core feature of the transducers makes them ideally suited to many retrofit applications where disconnection of the primary cable is not possible.

The magnetic sensing system and its Hall effect chips are mounted together with conducting electronics in a moulded black ABS plastic case which has a hinged top section which clips to the main body of the transducer. The transducer has a hole diameter of 19mm to accommodate the primary connection of the circuit being monitored.

Split core transducers can also easily accept multiple primary turns to increase the sensitivity of measurement, ie. increase of the primary ampere turns.

The output versions can be either instantaneous or true rms format with voltage or current options available. Connection of the output is by a 1.5m long screened cable suitable for connection into customer's own measurement circuitry.



Bipolar instantaneous measurement version

The 0-5V bipolar output option is suitable for the measurement of either alternating currents at the peak rating of the transducer and will provide an instantaneous representation of the primary waveform within the bandwidth specification.

Alternatively, because the units are employing Hall effect sensing, the 0-5V bipolar version can be used to measure dc values with positive or negative going currents within the rating of the chosen product.

Unipolar instantaneous measurement version

The 4 to 20mA unipolar version is designed for use primarily on dc circuits and will provide this standard industrial output for feeding a current loop system. Zero primary current will give an output of 4mA rising linearly to 20mA which corresponds to the rated current of the unit.

True rms measurement versions

Where it is necessary to convert an ac primary current signal into a true rms (dc) level there are versions available to provide either a 0-5V or 4-20mA output capable of feeding a variety of monitoring equipment.

Note: The 4-20mA output versions are floating outputs and should not be tied down to the zero of the power supply or grounded.

RS stock no. **Nominal current**	0-200A 0-300A 0-400A 0-500A	286-383 286-406	286-377 286-399 286-412 286-434	286-456 286-478 286-573	286-462 286-484 286-507
Output		4-20mA	0 ±5V	0-5Vdc	4-20mA
		Instantaneous		rms dc	
Supply voltage		±15V ±5%			
Supply current		25mA typical			
Accuracy @ 23°C		±1% of range			
Momentary overload		25,000 A.T. dc			
Signal conditioning		>200A/µs			
Frequency range		dc to 25kHz (small signal)			
Operating temp. range		0°C to +70°C			
Storage temp.		–10°C to +85°C			
Temp. coefficient		±0.05% of reading per °C			
Output impedance		–	<3Ω	<3Ω	–
Max. load impedance		500Ω	–	–	500Ω
Voltage withstand		5kVrms @ 50Hz for 1 minute			
Lead colour code					
	Red	+15Vdc			
	Blue	–15Vdc			
	Green	–ve load	0V	0V	–ve load
	White	+ve load	Output	Output	+ve load
	Screen	0V	–	–	0V

Selection/Cross reference chart-split core transducers

RS stock no.	Manufacturer's reference	Input (I_N)	Output
286-377	HT 200-SBD	0-200A	0-5V bipolar
286-383	HT 200-SID	0-200A	4-20mA unipolar
286-399	HT 300-SBD	0-300A	0-5V bipolar
286-406	HT 300-SID	0-300A	4-20mA unipolar
286-412	HT 400-SBD	0-400A	0-5V bipolar
286-434	HT 500-SBD	0-500A	0-5 bipolar

True rms versions

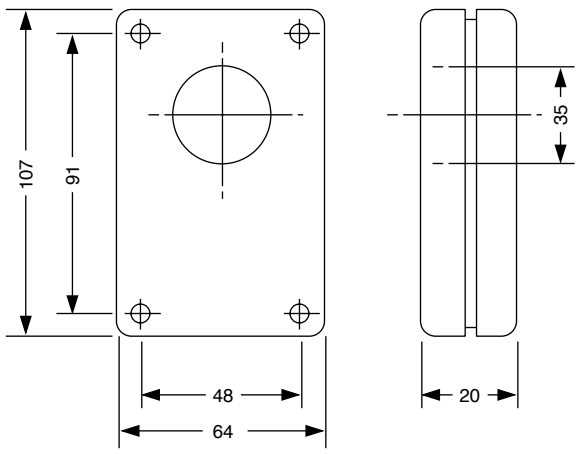
RS stock no.	Manufacturer's reference	Input (I_N)	Output
286-456	HT 200-SRUD	0-200A	0-5Vdc
286-462	HT 200-SRID	0-200A	4-20mAdc
286-478	HT 300-SRUD	0-300A	0-5Vdc
286-484	HT 300-SRID	0-300A	4-20mAdc
286-507	HT 400-SRID	0-400A	4-20mAdc
286-513	HT 500-SRUD	0-500A	0-5Vdc

Solid core transducers

This range of solid core current transducers employs Hall effect technology to enable the measurement of ac or dc currents. All versions supply an output that is linear to the current being monitored.

Two versions are available in measuring ranges of 0-200A (style 1) and 0-400A (style 2) with instantaneous or true rms versions available.

Figure 12 **Mounting dimensions**



Suitable mounting brackets
RS stock no. 544-213
Cable length 1.5m approx.

dc current transducers

The 0-10Vdc output options are ideal for use with instrumentation amplifiers and for local current indication via panel meters.

The 4-20mAdc output versions observe the process control industry standard, whereby zero current flow gives rise to a 4mA current flowing in the control loop rising linearly to a 20mA current flowing in the loop for the maximum current passing through the core

ac current transducers

The 0-10V bipolar output options are suitable for applications where monitoring of alternating currents up to 200A (style 1) or 400A (style 2) peak is required. The transducer's output is –10V for a current of –200A (style 1) or –400A (style 2) and +10V for a +200A (style 1) or + 400A (style 2) current.

rms current transducers

The rms current transducers provide an output which corresponds to the true rms value of the current when ac is measured, ie. the 4-20mA version gives a 4-20mAdc output for a current of 0-200A rms (style 1) or 0-400 A rms (style 2).

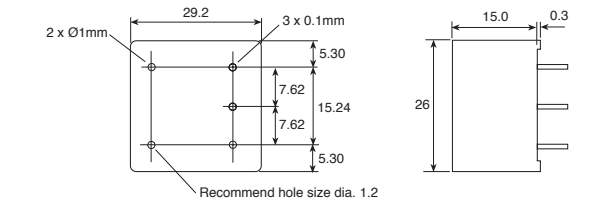
RS stock no. **Current range** **Style one: 0-200A** **Style two: 0-400A**		**257-414** **256-174**	**257-420** **256-180**	**257-436** **256-196**	**257-177** **256-203**	**257-183** **256-219**
Output		0-10Vdc	4-20mA	0-±10V	0-10Vdc	4.20mA
		Instantaneous			rms dc	
Supply voltage		±15V ±0.2Vdc				
Supply current		25mA typical				
Accuracy @ 23°C		±1% of range				
Momentary overload		25,000 A.T. dc				
Signal conditioning		>200A/µs				
Frequency range		dc to 25kHz (small signal)				
Operating temp. range		0°C to +60°C				
Storage temp.		+10°C to +70°C				
Temp. coefficient						
Output impedance		<3Ω	–	<3Ω	<3Ω	–
Max. load impedance		–	500Ω	–	–	500Ω
Voltage withstand		5kVrms @ 50Hz for 1 minute				
Lead colour code						
	Red	+15Vdc				
	Blue	–15Vdc	–ve load	–15Vdc	–15Vdc	–15Vdc
	Green	0 volts				–ve load
	White	Output	+ve load	Output		+ve load
	Screen	–	–	–	–	0 volts

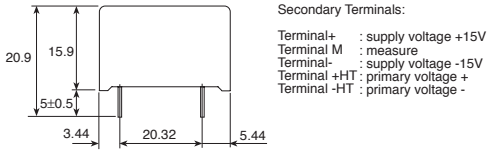
Selection/Cross reference chart – solid core transducers

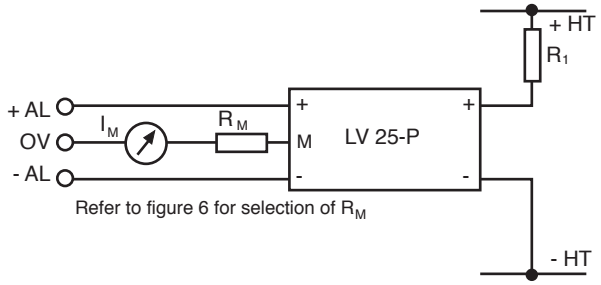
RS stock no.	Manufacturer's reference	Input	Output	Supply voltage
Style 1				
257-414	HA 200-SU	0-200Adc	0-10Vdc	±15V ±0.2V
257-420	HA 200-SI	0-200Adc	4-20mAdc	±15V ±0.2V
257-436	HA200-SB	0-200Aac	0- ±10V bipolar	±15V ±0.2V
257-177	HA 200-SRU	0-200Aac rms	0-10Vdc	±15V ±0.2V
257-183	HA 200-SRI	0-200Aac rms	4-20mAdc	±15V ±0.2V
Style 2				
256-174	HA 400-SU	0-400Adc	0-10Vdc	±15V ±0.2V
256-180	HA 400-SI	0-400Adc	4-20mAdc	±15V ±0.2V
256-196	HA 400-SB	0-400Aac bipolar	0 ±10V bipolar	±15V ±0.2V
256-203	HA 400-SRU	0-400Aac rms	0-10Vdc	±15V ±0.2V
256-219	HA 400-SRI	0-400Aac rms	4-20mAdc	±15V ±0.2V

Voltage transducer, PCB mounting
RS stock no. 286-361

This PCB mounting voltage transducer, based on the use of Hall effect, is suitable for the electronic measurement of voltages associated with dc, ac and impulse circuits. The unit provides galvanic isolation between the primary and secondary circuits. To enable a voltage to be measured a current proportional to the measured voltage must be collected through an external resistor, selected by the user, in series with the primary circuit of the unit.







Refer to Figure 6 for selection of R_M

Indications for use of the voltage transducer model LV 25-P

Primary resistor R1: The transducer's optimum accuracy is obtained with the nominal primary current. As far as possible, R1 will be calculated so that the nominal voltage to be measured corresponds to a primary current of 10mA.

Example: Voltage to be measured UN = 250V

a) R1 = 25 kΩ/10W,I prim. = 10mA, accuracy = ± 0.6 % of UN at +25°C

b) R1 = 50 kΩ/5W,I prim. = 5mA, accuracy = ± 1.2 % of UN at +25°C

Operating range (recommended) : Taking into account the resistance of the primary windings (which must remain low compared to R1, in order to keep thermal deviation as low as possible) and the isolation, this transducer is suitable for measuring nominal voltages of 10 to 500V.

Technical specification

Output type	Instantaneous
Nominal current I_N	10mA
Nominal analogue output current	25mA
Turns ratio	2500:1000
Overall accuracy at +25°C	±0.6% of I_N
Supply voltage	±15V (±5%)
Isolation	2.5kVrms/50Hz/1 min.
Linearity	<0.2%
Response time	40µs for R1 series 25kΩ resistor
Operating temperature	0°C to +70°C
Storage temperature	–25°C to +85°C
Current consumption	10mA + output current
Primary internal resistance	250Ω
Secondary internal resistance	110Ω
Weight	22g
Package	Potted into an insulated self extinguishing plastic case
Polarity markings	A positive output current is obtained on terminal M when a positive voltage is applied on terminal +HT of the primary circuit
Connection to primary circuit	By 2 pins 1mm diameter
Connection to secondary circuit	By 3 pins 1mm diameter