

## A40B Series Precision Current Shunts

Precision, low inductance shunts for dc and ac current metrology

### Technical Data

The Fluke A40B Precision Current Shunts simplify and improve metrology for dc and ac current. Used to measure current from 1 mA to 100 A, the shunts ensure reliable and traceable results. For many applications, improved resistor technology enables you to make accurate ac current measurements in a single step, instead of using traditional, more complex ac/dc transfer methods.



Intended for broad coverage of current measurement applications, the A40B Set consists of 14 low-inductance coaxial current shunts, leads, adapters and connectors, plus a rugged case for transit and storage. Together they cover a wide workload that includes electrical calibrators, electrical power standards, current sources, transconductance amplifiers, and more. You can purchase the entire set or individual shunts as required for your application and budget.

#### Designed for top performance and ease of use

The physical construction and the components used in the current shunts ensure that the frequency response is very flat (amplitude displacement error relative to dc resistance). The phase displacement

at 100 kHz is small enough to be neglected in all but the highest accuracy measurements. Combined with excellent dc resistance stability, the shunts can be used to directly measure current through their full bandwidth. This simplifies precision ac current measurements, so the complex ac/dc transfer measurement process will no longer be necessary for many precision current measurement applications.

The low phase shift error is critical for measurement of non sinusoidal wave shapes, as found in power quality or sampling digital wattmeter measurement applications.

The A40B current shunts feature a radial design for high performance with minimum interference from external magnetic fields. The open design maximizes air flow so the shunts have minimal power coefficient effects, enabling them to be used over a wide range of currents with stable resistance.

#### A40B features at a glance

- Simplify calibration/verification of precision calibrators and current sources
- Shunts sized for currents from 1 mA to 100 A
- Usable from dc to 100 kHz
- 14 individual shunts with a 1, 2, 5 sequence over six decades of current
- Simple direct measurements, making ac/dc transfers unnecessary
- Stability typically better than  $\pm 5.0 \mu\Omega/\Omega$  for one year
- Typical angular accuracy of better than  $\pm 0.003^\circ$  at 1 kHz



## Widest range available in commercial shunts

The A40B shunts come in four sizes and a wide range of currents:

- Four fully enclosed shunts: 1 mA, 10 mA, 20 mA, 50 mA
- Five small radial shunts: 100 mA, 200 mA, 500 mA, 1 A, 2 A
- Three medium radial shunts: 5 A, 10 A, 20 A
- Two large radial shunts: 50 A, 100 A

An external cooling fan is not required. The shunts are the first commercially available product to feature this design.

The 4-terminal design completely isolates measured voltage from extraneous current path resistance. Current does not flow in the voltage circuit, allowing you to measure with the highest accuracy.

Optional adapters allow you to make connections with commonly used N connectors as well as LC connectors for high current applications.

The 1 mA shunt includes an internal battery operated buffer amplifier to isolate the voltage measurement circuit from the current circuit. This enables you to use the shunt to make low current measurements at optimal voltage levels, while eliminating the effects of input impedance of the measurement device.

### Single step convenience

In the past, complex ac/dc transfer techniques were required to verify ac current functions on calibrators. With current accuracy to 20 ppm and excellent dc resistance stability, the A40B shunts measure ac currently directly through their full bandwidth. For

many applications, ac-dc transfer measurements will not be necessary. A simple measurement of the shunt, using a precision digital multimeter like the Fluke 8508A, can reduce measurement complexity by two thirds.

### Versatile solutions for many applications

The shunts' output voltage is nominal at 0.8 V, making them compatible with a wide range of devices including precision digital multimeters, ac-dc transfer standards, ac measurement standards, thermal voltage converters and sampling digital multimeters.

Low inductance and low phase displacement make the A40B shunts an excellent fit for power measurement or digital sampling wattmeter measurement applications where phase accuracy and stability are critical.

The wide current range allows verification of high current transconductance amplifiers.

### Report of traceable calibration included

The A40B series comes standard with a report of traceable calibration including data. An optional ISO 17025 accredited report of calibration is available.

## Electrical Specifications

### Absolute accuracy

The following table shows the 1-year absolute accuracy specification stated at k=2, approximately 95 % confidence for the calibrated value. The specifications include 1-year stability, temperature effects over TCal ± 1 °C, and the measurement uncertainty of the calibrated value.

Shunt Nominal Current	Nominal Resistance (Ohms)	Specification ± µA/A, TCal ±1 °C, ≤ 50 % RH <sup>1,2,3,5</sup>				
		DC	1 kHz	10 kHz	30 kHz	100 kHz
1 mA <sup>4</sup>	800	20	55	75	75	150
10 mA	80	20	26	26	26	26
20 mA	40	20	26	26	26	26
50 mA	16	20	23	23	23	23
100 mA	8	20	24	24	24	24
200 mA	4	20	26	26	26	26
500 mA	1.6	21	27	27	27	28
1 A	0.8	21	27	28	28	31
2 A	0.4	21	27	30	30	48
5 A	0.16	21	31	32	40	71
10 A	0.08	26	37	60	61	92
20 A	0.04	26	43	52	70	113
50 A	0.016	32	55	80	81	144
100 A	0.008	35	65	90	98	174

<sup>1</sup> The measured current is determined from:  $I = (V/R_{\text{calibrated}}) \times (1 + (\text{AC-DC}_{\text{calibrated}}/1,000,000))$ ; where AC-DC<sub>calibrated</sub> is expressed in ppm.

<sup>2</sup> Above 1 kHz interpolate the specification ( $s_i$ ) between frequencies  $f_{\text{upper}}$  and  $f_{\text{lower}}$  using:

$$s_i = s_{\text{lower}} + (f_i - f_{\text{lower}}) \times (s_{\text{upper}} - s_{\text{lower}}) \div (f_{\text{upper}} - f_{\text{lower}})$$

<sup>3</sup> Add 20 µA/A if relative humidity is outside specification limits.

<sup>4</sup> 1 mA specifications apply with the battery charger disconnected.

<sup>5</sup> Specifications assume no loading effects due to the voltage-sensing device. See *Output Voltage Measurement – Loading Effects* in the operating information.

### Resistance

Shunt Nominal Current	Nominal Resistance (Ohms)	Maximum Deviation from Nominal Resistance (± µΩ/Ω) <sup>2</sup>	Uncertainty of Cali- brated Value at 95 % Confidence (± µΩ/Ω) TCal ± 1 °C	12 Month Stability (± µΩ/Ω) <sup>1,2</sup>	Temperature Coefficient (± ppm/°C) <sup>2</sup>	Power Coefficient Multiplier (± ppm) <sup>2,3</sup>
1 mA	800	250	8.2	18	5	1
10 mA	80	250	6.8	18	2.5	1
20 mA	40	250	8.2	18	4.5	1
50 mA	16	250	8.3	18	4.5	1
100 mA	8	250	8.3	18	2.5	2
200 mA	4	250	8.6	18	3.5	4
500 mA	1.6	250	9.6	18	4.5	13
1 A	0.8	250	9.3	18	4.5	26
2 A	0.4	250	9.4	18	4.5	26
5 A	0.16	250	9.9	18	4.5	30
10 A	0.08	250	15	18	4.5	65
20 A	0.04	250	14	18	4.5	78
50 A	0.016	250	24	18	4.5	105
100 A	0.008	250	28	18	4.5	105

<sup>1</sup> Stability specification combines long term change due to aging (permanent) and short term fluctuation due to humidity changes when shunts are used and stored within specified humidity limits. Add 20 ppm if humidity is >50 % RH).

<sup>2</sup> Assume rectangular distribution when combining with other uncertainty contributions.

<sup>3</sup> Calibrated resistance values include the effects of power coefficient at the nominal current. For currents other than nominal, apply the correction for power coefficient from:  $\text{Correction} = \text{Power\_Coefficient\_Multiplier} \times \left[ 1 - \left( \frac{I_{\text{Applied}}}{I_{\text{Nominal}}} \right)^2 \right]$

<sup>4</sup> TCal = ambient temperature at calibration.

## Maximum AC-DC difference

Shunt Nominal Current	Maximum AC-DC Difference ( $\pm$ ppm) <sup>1,2</sup>			
	1 kHz	10 kHz	30 kHz	100 kHz
1 mA <sup>3</sup>	53	72	72	150
10 mA	20	20	20	40
20 mA	18	18	19	30
50 mA	13	13	14	16
100 mA	14	15	17	27
200 mA	17	17	18	28
500 mA	17	17	17	21
1 A	17	19	19	23
2 A	17	22	22	44
5 A	23	24	34	69
10 A	28	55	58	98
20 A	37	51	80	150
50 A	47	75	79	180
100 A	60	90	120	300

<sup>1</sup> Specifications indicate the maximum flatness deviation from dc, and include both measured AC-DC difference and the uncertainty of measurement. They are stated at k=2, approximately 95 % confidence.

<sup>2</sup> Includes 1-year stability of the AC-DC difference.

<sup>3</sup> Specifications for the 1 mA current shunt are for TCal  $\pm$  1 °C.

## Maximum overload current

Shunt Nominal Current	Maximum Current < 5 seconds <sup>1</sup>	Maximum Sustained Current <sup>2</sup>	Shunt Nominal Current	Maximum Current < 5 seconds <sup>1</sup>	Maximum Sustained Current <sup>2</sup>
1 mA	3 mA	2 mA <sup>3</sup>	1 A	3.9 A	1.3 A
10 mA	150 mA	20 mA	2 A	5.5 A	2.2 A
20 mA	250 mA	40 mA	5 A	17 A	5.5 A
50 mA	450 mA	100 mA	10 A	24 A	11 A
100 mA	1.2 A	200 mA	20 A	42 A	22 A
200 mA	1.7 A	400 mA	50 A	95 A	55 A
500 mA	2.7 A	1 A	100 A	190 A	110 A

<sup>1</sup> Longer than 5 seconds may cause permanent damage to the shunt. The output voltage may be considerably higher than 0.8 V.

<sup>2</sup> Exceeding maximum sustained current may cause a resistance value step change.

<sup>3</sup> 1 mA shunt batteries should be fully charged to ensure performance at 2 mA.

## Typical phase displacement

Typical Phase Displacement			
Shunt Nominal Current	1 kHz	10 kHz	100 kHz
1 mA to 200 mA	< 0.001 °	< 0.006 °	< 0.060 °
500 mA to 2 A	< 0.003 °	< 0.030 °	< 0.300 °
2 A to 20 A	< 0.008 °	< 0.075 °	< 0.750 °
20 A to 100 A	< 0.013 °	< 0.125 °	< 1.250 °

## General specifications

### Dimensions (maximum)

Shunt Value	Height mm (inches)	Width mm (inches)	Overall Length <sup>1</sup> mm (inches)
1 mA to 2 A	70 (2.75)	70 (2.75)	124 (4.9)
5 A to 20 A	130 (5)	130 (5)	210 (8.25)
50 A and 100 A	200 (7.9)	200 (7.9)	343 (13.5)

<sup>1</sup> Includes input and output connectors; subject to change by component vendor.

### Physical/mechanical parameters

Shunt Value	Weight (maximum) kg (lb)	Input Connector	Output Connector
1 mA to 20 A	0.7 (1.6)	Type-N (female)	Type-N (female)
50 A and 100 A	3.4 (7.5)	Type-LC (female)	Type-N (female)

### Operating environment

**Temperature:** 13 °C to 33 °C

**Calibration temperature (TCal) range:** 18 °C to 28 °C

**Humidity range for best specification<sup>1,2</sup>:** ≤ 50 %

RH

**Altitude:** 0 m to 3,000 m

<sup>1</sup> Resistance stability is affected by humidity, but changes are reversible.

<sup>2</sup> If the shunts are calibrated outside this RH, stability specifications will be met as long as the shunts are stored and used at the same relative humidity ± 10 % RH.

### Storage and transit environments

(for models other than the 1 mA current shunt)

**Temperature to avoid damage:** -20 °C to 140 °C

**Temperature and humidity to maintain performance<sup>1</sup>:** 5 °C to 45 °C; 15 % to 80 % RH

**Non-operating altitude:** 0 m to 12,000 m

<sup>1</sup> Storage at extremes of temperature or humidity will cause a temporary change of shunt resistance by up to ± 20 ppm. When subsequently stored or used within the limits of the operating environment, the shunts will recover to their original resistance value within 30 days.

### Additional 1 mA current shunt specifications

**Output resistance:** 8 mΩ

**Maximum safe output current:** 11 mA (e.g., 1 V output into 90 Ω)

**Maximum capacitive load:** 800 pF

**Output voltage regulation:** 15 ppm/100 pF

**Maximum output dc v offset:** ± 100 μV

(typical ± 25 μV)

**Typical error @ 1 MHz:** < 2 %

### Battery specifications

**Battery size:** AAA (44.5 mm x 10.5 mm)

**Battery technology:** Nickel-Metal Hydride (NiMH)

**Number of batteries required:** 8 (in 2 groups of 4)

**Nominal battery voltage:** 1.2 V (4.8 V per group of 4)

**Typical battery capacity:** 800 mAh

**Storage and transit environment to preserve the batteries**

**Less than 90 days:** -20 °C to 40 °C

**Less than one year:** -20 °C to 30 °C

**Charging time (from fully discharged):** 100 minutes

**Maximum operating time between charges**

**Maximum output load (11 mA):** 18 hours

**High impedance load:** 24 hours

**Recommended cooling period:** 100 minutes

To prevent loss of battery capacity recharge at least twice per year.



## Ordering Information

### Models

A40B/SET	Complete set of 14 shunts with recommended connectors and adapters, leads and transit case.
A40B-001MA	1 mA Current Shunt
A40B-010MA	10 mA Current Shunt
A40B-020MA	20 mA Current Shunt
A40B-050MA	50 mA Current Shunt
A40B-100MA	100 mA Current Shunt
A40B-200MA	200 mA Current Shunt
A40B-500MA	500 mA Current Shunt
A40B-1A	1 A Current Shunt
A40B-2A	2 A Current Shunt
A40B-5A	5 A Current Shunt
A40B-10A	10 A Current Shunt
A40B-20A	20 A Current Shunt
A40B-50A	50 A Current Shunt
A40B-100A	100 A Current Shunt

### Options and accessories

A40B-ADAPT/LC	LC Male to LC Male adapter <sup>1</sup>
A40B-ADAPT/LCN	LC Female to N Male inter-series adapter <sup>1</sup>
A40B-APAPT/SPADE	LC Male to Spade Terminal Adapter
A40B-LEAD/4MM	N to 4 mm double banana connector <sup>2</sup>
A40B-LEAD/N	N male to N male lead <sup>1</sup>
A40B-CASE	Fiberglass Transit Case
1883673	UKAS Accredited Calibration

<sup>1</sup>A quantity of one of this accessory item is included in the A40B/SET

<sup>2</sup>A quantity of two of this accessory item is included in the A40B/SET

### Specialized accessories (recommended when calibrating A40B series shunts)

A40B-CAL/LC	High current adapter to connect two shunts in series for measurement (LC to LC)
A40B-CAL/N	Low current adapter to connect two shunts in series for measurement (N to N)



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**Fluke Calibration**  
PO Box 9090,  
Everett, WA 98206 U.S.A.

**Fluke Europe B.V.**  
PO Box 1186, 5602 BD  
Eindhoven, The Netherlands

#### For more information call:

In the U.S.A. (877) 355-3225 or Fax (425) 446-5116  
In Europe/M-East/Africa +31 (0) 40 2675 200 or Fax +31 (0) 40 2675 222  
In Canada (800)-36-FLUKE or Fax (905) 890-6866  
From other countries +1 (425) 446-5500 or Fax +1 (425) 446-5116  
Web access: <http://www.flukecal.com>

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**Cal Power**

Via Acquarana, 29 22100 COMO  
tel. 031.526.566 (r.a.) fax 031.507.984  
[info@calpower.it](mailto:info@calpower.it) [www.caltower.it](http://www.caltower.it)