PMK Probing Solutions. Made in Germany.

Ultra-Fast Current Shunt Series UFCS

>1 GHz Bandwidth, <200 pH Insertion Inductance
Various sizes available: 1 mΩ – 52 mΩ

PRELIMINARY Instruction Manual

Manufacturer

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Warranty

PMK warrants this product for normal use and operation within specifications for a period of one year from date of shipment and will repair or replace any defective product which was not damaged by negligence, misuse, improper installation, accident or unauthorized repair or modification by the buyer. This warranty covers defects in materials and workmanship only and does not cover wear and tear. PMK disclaims any other implied warranties of merchantability or fitness for a particular purpose. PMK will not be liable for any indirect, special, incidental, or consequential damages (including damages for loss of profits, loss of business, loss of use or data, interruption of business and the like), even if PMK has been advised of the possibility of such damages arising from any defect or error in this manual or product.

Declaration of Conformity

CE

PMK declares the conformity of this product with the actual required safety standards:

The basis on which conformity is being declared:

EN IEC 61326-1:2021	Electrical equipment for measurement, control and laboratory use – EMC requirements - Part 1: General requirements
EN IEC 61000-4-2:2008	Electromagnetic compatibility (EMC) –Part 4-2: Testing and measurement techniques –Electrostatic discharge immunity test
EN IEC 61010-1:2020	Safety requirements for electrical equipment for measurement, control and laboratory use Part 1: General safety requirements for electrical equipment for measurement, control, and laboratory use.

WEEE/ RoHS Directives

This electronic product is classified within the WEEE/ RoHS category list as monitoring and control equipment (category 9) and is compliant to the following EC Directives.

WEEE Directive 2012/19/EU	Waste Electrical and Electronic Equipment
RoHS Directive 2011/65/EU	Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment

Your help and efforts are required to protect and keep clean our environment. Therefore, return this electronic product at the end of its life either to our Service Department or take care of separate WEEE collection and professional WEEE treatment yourself. Do not dispose as unsorted municipal waste.

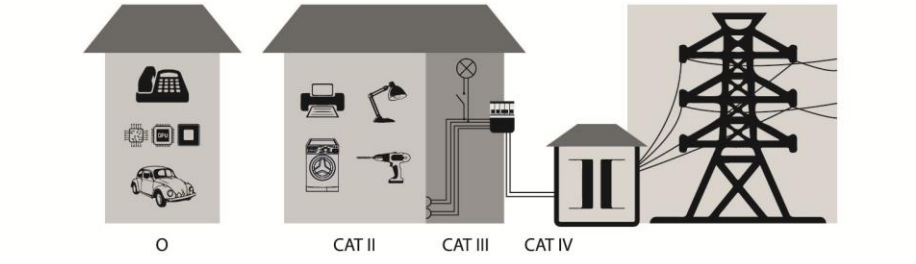
Table of Contents

IEC Safety Information

IEC Measurement Categories

This probe series is not rated for CAT II, III or IV.

Definitions and Examples:



Overview of measurement categories according to IEC 61010-01
O = No Measurement Category (Other circuits that are not directly connected to mains)

IEC Pollution Degree

Pollution Degree 1	No POLLUTION or only dry, nonconductive POLLUTION. NOTE: The POLLUTION has no influence.
Pollution Degree 2	Only- nonconductive POLLUTION. Occasionally, however, a temporary conductivity caused by condensation must be accepted.
Pollution Degree 3	Conductive POLLUTION occurs or dry, non-conductive POLLUTION occurs which becomes conductive due to condensation which is to be expected.

IEC Safety Symbols

The following symbols may appear on the product or in this instruction manual:


Caution, risk of danger. Refer to manual.


Caution, risk of electric shock.


Earth (ground) TERMINAL.


Caution, hot surface

Safety and Handling Information

Read the Instruction Manual before first use and keep it for future reference. A digital copy of the latest Instruction Manual revision can be downloaded at www.pmk.de.

This shunt series is for use with qualified personnel only. The overall safety of any measurement setup incorporating this probe is the responsibility of the user. To prevent electrical accidents, read the safety instructions carefully. Observe the five safety rules of the German standard series EN 50110-1.

Position and handle the shunt only when the circuit under test is de-energized.
Use non-handheld and in test setups with safety environment only.
This shunt is not for hand-held use. Install the shunt in a safety protected test environment and make all required connections and configurations before starting the measurements. The shunt's outer casing and cable shields will become energized to the "shield" potential of the probe, these must be included within the safety environment. In the event of a fault the probe casing may become energized to other potentials within the circuit under test.

Caution, hot surface. The shunt body may become hot during measurements and soldering installation. Use appropriate protective equipment.

Prevent personal injury, fire and product damage.
To avoid personal injury and to prevent fire or damage to this product or products connected to it, review and comply with the following safety precautions. Be aware that if you use this probe assembly in a manner not specified the protection this product provides may be impaired. Only qualified personnel should use this probe assembly.

Connect securely to the circuit under test.
Connect the shunt output to the measurement circuit securely and with a reliable electrical contact. A poor or unreliable electrical contact may lead to arcing, heat generation, burning, fire and arc flash.

Observe probe and probe accessory ratings.
Do not apply any electrical current or potential to the shunt input which exceeds the maximum ratings of the shunt, or the accessories connected to it. In case of a combination, always the lower rating / measurement category applies to both probe and accessories connected to it.

Keep away from hazardous live circuits.
Avoid open circuitry. Do not touch connections or components when power is present.

Do not operate with suspected failures.
Refer to qualified service personnel.

Indoor use only.
Do not operate in wet or damp environment. Keep the product dry and clean.

Do not operate the product in an explosive atmosphere.

The max. input current decreases as the duration of the applied signal increases (see Current Derating curve).
See the relevant section of this manual for further information on maximum input current, and current derating.

Safety and Handling Information (continued)

When using un-isolated equipment, connect the “shield” terminal of the probe to earth ground.
The shunt is not isolated. If the “shield” is connected to a different potential, then a “short circuit” will be present through the oscilloscope.

Note that the connections are sensitive. Do not damage through excessive bending or pulling. Avoid mechanical shock to this product in general to guarantee accurate performance and protection.

Any accessories provided with the shunt have been safety tested. Do not use any other accessories than those “originally” provided or recommended.

The Ultra-Fast Current Shunt series UFCS

The Ultra-Fast Current Shunts (UFCS) represent a paradigm shift in the realm of current measurement technology, setting new standards in terms of technological sophistication. >1GHz bandwidth and ultra-low insertion inductance of <200pH enable the precise analysis of fast rise time signals with exceptional signal fidelity, making PMK's shunts with non-inductive frequency response ideal for challenging measurements like WBG (wide-bandgap) switching loss or pulse current analysis.

The UFCS models' compact form factor and high current carrying capacity ensure consistent and reliable performance. Whether measuring GaN switching losses or analyzing high-frequency transients, the solder-in shunts always guarantee highest accuracy.

The UFCS are a result of technological advancement that has not been surpassed in the field of current measurement in modern power electronics. For measurements with highest CMRR requirements the UFCS can be connected to optically isolated voltage probes, like PMK's FireFly®. For general purpose measurements the UFCS can also be connected directly to an 50 Ω input measuring instrument.

The first model releases of the UFCS shunt series are the 11 mΩ, 24 mΩ and 52 mΩ versions.

Specifications

Read the Instruction Manual before first use and keep it for future reference. A digital copy of the latest Instruction Manual revision can be downloaded at www.pmk.de.

Electrical Specifications

Allow the shunt to warm up for 20 minutes. This shunt comes with 1 year warranty. Each specification is determined at +23°C ambient temperature. Do not exceed the specifications.

PMK's UFCS ultra-fast current shunts are for use in a controlled environment in accordance with IEC 61010-1 only. The shunts are not for hand-held use. This product is not rated for CAT II, III or IV. Do not exceed the specifications[1].

Order number	Shunt Resistance	Gain	Bandwidth (3dB)	Typical Insertion Inductance [3]
UFCS-R001	1 mΩ	TBD	TBD	TBD
UFCS-R005	5 mΩ	TBD	>800 MHz	TBD
UFCS-R011	11 mΩ	10.7 mV/A	>1 GHz	110 pH
UFCS-R024	24 mΩ	23.7 mV/A	>1 GHz	140 pH
UFCS-R052	52 mΩ	51.1 mV/A	>900 MHz	150 pH

Order number	Maximum 1us Pulse Current [2]	Maximum 100us Pulse Current [2]	Continuous Current [2, 4]
UFCS-R001	TBD	TBD	TBD
UFCS-R005	TBD	TBD	TBD
UFCS-R011	340 A	105 A	7.3 A
UFCS-R024	230 A	70 A	4.9 A
UFCS-R052	160 A	50 A	3.4 A

Notes:
[1] Electrical Specifications[1] that are not marked with (*) as guaranteed are typical.
Performance parameters may vary if not using the recommended footprint.
[2] See Maximum Current per Pulse Length graph.
[3] When soldered into recommended footprint, measured at 5-10 MHz, does not include footprint inductance.
[4] Preliminary – measured at room temperature

The following specifications are valid for all models of the UFCS series:

Pollution Degree: 1

Gain Accuracy: 1 %

Output connector: SMA (female)

Input Coupling of the Measuring Instrument: 50 Ω

Exceeding the specified ratings may cause irreversible failure and damage to the connected equipment.

The ratings may vary depending on usage conditions and usage environment. The provided data is intended as a reference only.

Environmental Specifications

Parameter		Specification
Temperature Range	**Operating**	-40 °C to +85 °C -40 °C to +30 °C under non-pulsed current conditions
	Non-Operating	-40 °C to +85 °C
Maximum Relative Humidity	**Operating**	80 % relative humidity for temperatures up to +31 °C, decreasing linearly to 40 % at +50 °C, non-condensing humidity
	Non-Operating	95 % relative humidity for temperatures up to +40 °C, non-condensing humidity
Altitude	**Operating**	up to 2000 m
	Non-Operating	up to 15000 m

Please contact sales@pmk.de, if another temperature range is of interest.

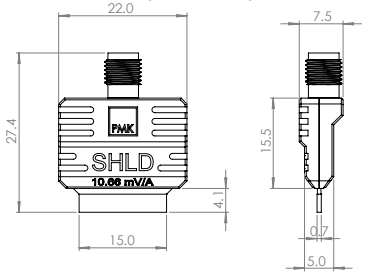
Mechanical Specifications

Parameter	Shunt Specifications	UFCS-Choke Specifications
Weight	TBD	TBD
Dimensions	See drawing [5]	L = TBD, choke Ø TBD
Input	Soldering Pads [5]	SMA (male)
Output Connector	SMA (female)	BNC (male)
Input Coupling of the Measuring Instrument [6]	50 Ω	

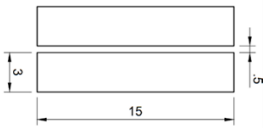
Notes:
[5] See section “Dimensional Drawing and Recommended Footprint”
[6] Or 1M Ω input impedance and a 50 Ω feed-through termination, see ordering information

Dimensional Drawing and Recommended Footprint

The schematical drawing and all dimensions in the recommended footprint drawing are shown in [mm]. Contact sales@pmk.de or your local PMK representative for design files. Drawings not to scale.



Observe Solder-in direction: UFCS IN for input, SHLD for reference (internally connected to output connector shield).

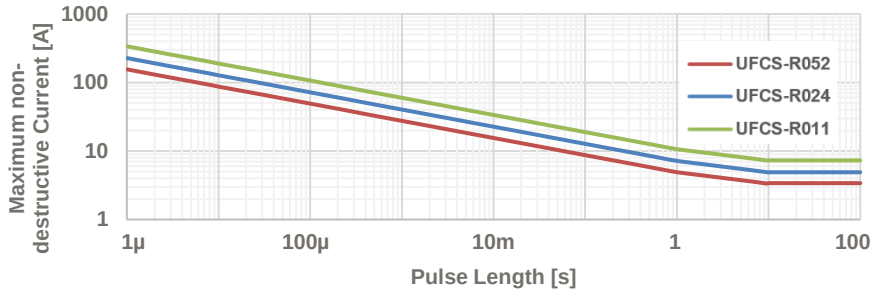


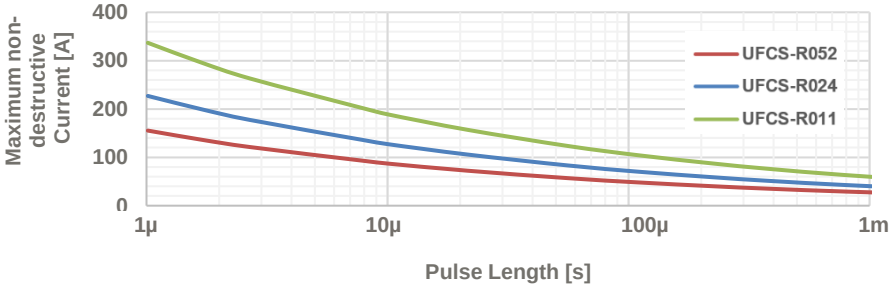
Maximum Pulse Current Derating

Exceeding the maximum pulse rating of the UFCS can cause irreversible damage to the product and connected accessories.

Always check that output voltage is compatible with ratings of oscilloscope or isolated probe.
$V_{OUT,SHUNT}$ = Shunt Gain X Test Current.

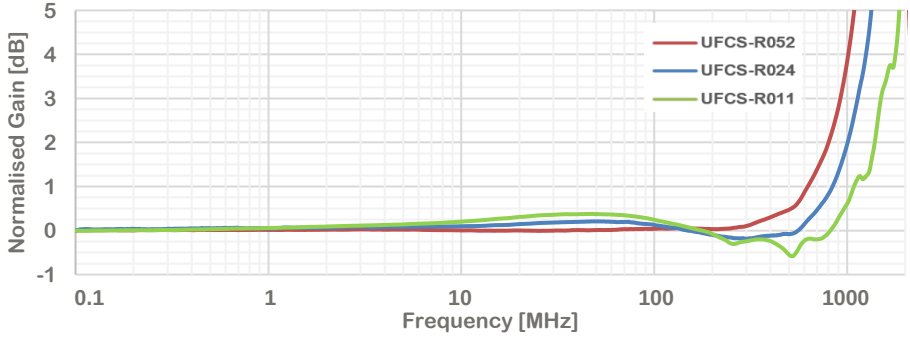
UFCS-R0XX Maximum Pulse Current Ratings (Preliminary Calculated Data)





Frequency Response

UFCS-R0XX Frequency Response (Preliminary Calculated Data)



The Frequency Response graphs are normalised to 0 dB for better comparison.

Getting Started

About the UFCS Connections

The UFCS shunt can most simply be considered as a 4-wire resistor. Current goes into and out of the Input terminals (IN and SHLD). The output voltage is measured across the “SMA output connector” which must be terminated into a 50 Ω load.

Current can pass through the input terminals in any direction so long as ground referencing of the “SHLD” terminal is observed. By reversing the input current polarity, the polarity of the output signal will be reversed.

The “shield” of the “SMA output connector” is directly connected to the “SHLD” input terminal. The centre conductor of the SMA connector is not isolated from the input and is referenced to the other terminals.

Input Connections

To achieve the lowest insertion inductance of the UFCS it is best to install it using a solder connection using the footprint recommended in the “Dimensional Drawing and Recommended Footprint” section of this manual.

To aid installation/removal of the shunt and prolong its life it is recommended to use a low melting point solder such as CHIPQUIK SMDSWLT.040. Reflow soldering of the probe using a reflow oven or hot air is not recommended.

When soldering, the shunt body may become hot, please hold the shunt with a tool (e.g. pliers) or heatproof gloves.

The shield side, indicated by “SHLD”, is directly connected to the shield of its output’s coaxial connection.

Connect the UFCS shield side properly in isolated and non-isolated measurements to prevent measurement errors and system damage.

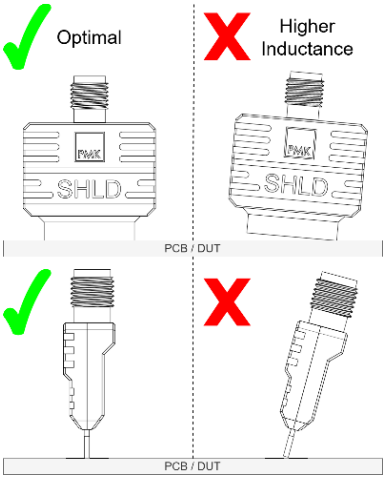
If galvanically isolating the shunt with an optically isolated probe, such as PMK’s FireFly® series probes, observe the safety and handling instructions in the referring user manual.

If the shunt is operated without galvanic isolation, then the “SHLD” terminal must share the ground of the measuring instrument

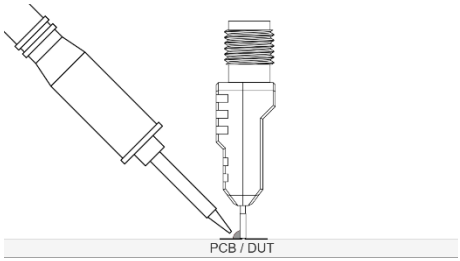
Recommended Soldering Technique

Follow the steps 1 to 4.

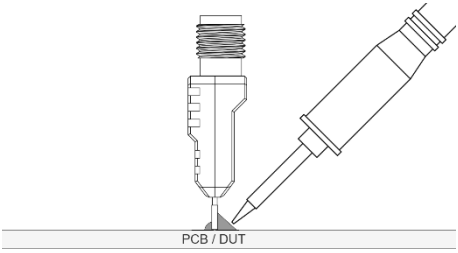
1. Hold the shunt perpendicular to the PCB and aligned to the footprint, avoid any gaps between the shunt and the PCB - these will increase insertion inductance.



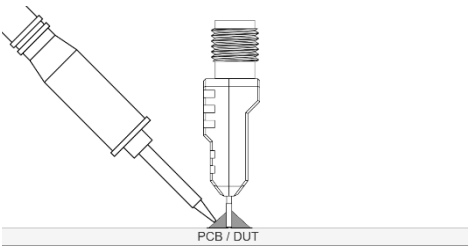
2. “Tack” one side of the shunt with solder to hold it into position. It may be helpful to “tin” the shunt and PCB pad on this side first.



3. Solder the opposite side of the probe with a complete solder fillet.



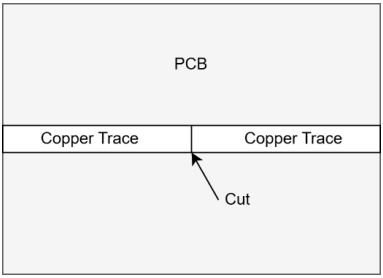
4. Resolder the tacked side of the probe with a complete solder fillet.



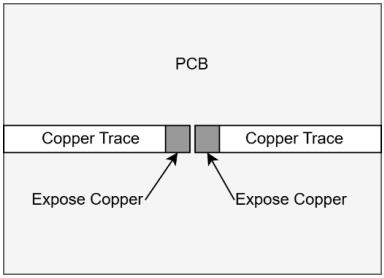
Other Input Connection Methods

If it is not possible to use the recommended footprint then it is possible to solder the shunt across an existing PCB trace.

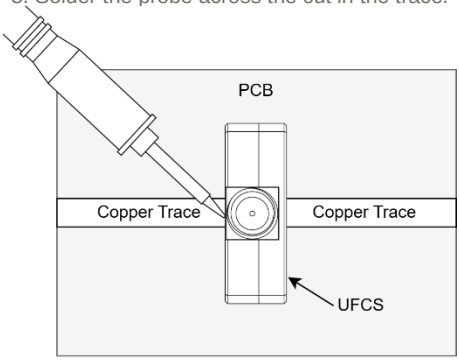
1. Carefully cut the PCB trace where you wish to install the UFCS.



2. Remove solder mask to expose some copper each side of the trace, “tin” the exposed copper with solder.

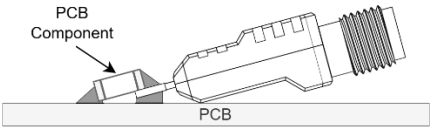


3. Solder the probe across the cut in the trace.



The shunt can also be soldered between a component and the PCB.

Example



Output Connections

Ground-referenced (un-isolated) Measurements

The “SMA output connector” of the UFCS shunt can be connected to any 50 Ω input terminated measurement instrument (e.g. oscilloscope). When doing this the “SHLD” terminal of the UFCS become referenced to the input shield of the measuring instrument.

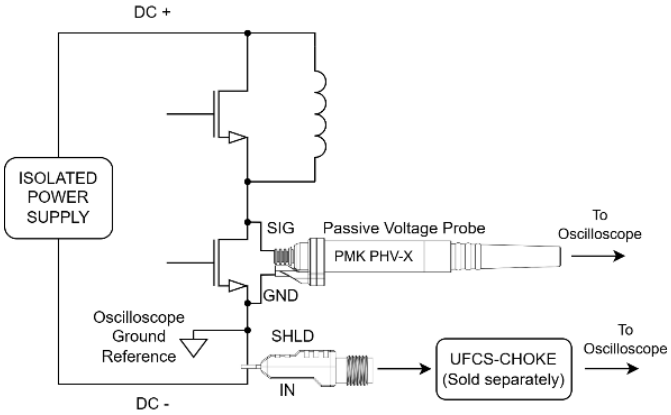
Observe the maximum voltage and power ratings of the measuring instrument in relation to the gain of the UFCS.

If the maximum current rating of the shunt is exceeded, not only the shunt may be damaged but also high circuit voltages may become present on its output. This can also cause damage to the measurement instrument (e.g. oscilloscope). To reduce risk, an external 50 Ω termination (see “Ordering Information”) may be used with the measurement instrument set to 1 MΩ mode. This mode of the measurement instrument typically has a higher maximum input voltage rating.

To prevent transmission line reflections and ringing when using a 50 Ω termination, the termination should be placed as close as possible to the receiving measurement instrument (e.g. on the channel BNC connector of the oscilloscope).

When performing a ground-referenced measurement it is highly recommended to place a common mode choke, see “Ordering Information”, between the UFCS and the oscilloscope. Without this, common mode noise may cause measurement error.

Typical non-isolated double pulse test configuration

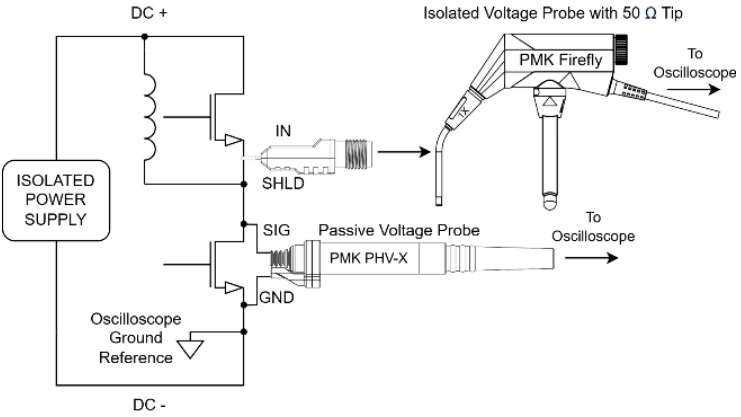


Standard 50 Ω transmission line accessories, such as attenuators and overvoltage line protectors may be used in conjunction with the UFCS.

Isolated Measurements

For isolated measurements the UFCS may be connected to the PMK FireFly® Optically Isolated Probe through one of the FireFly® 50 Ω terminated probe input tip cables and SMA-MMCX adapter. Review the probe's Ordering Information.

Typical isolated "high side" current measurements in a double pulse test configuration



Standard 50 Ω transmission line attenuators may also be used in conjunction with this method to extend the measurement range.

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Scope of Delivery

See chapter “Ordering Information” to review the selection of accessories for connections to different measuring instruments.

UFCS series shunt

Instruction manual

Ordering Information

Step 1: Select the Shunt

Each resistance model is available as a single pack or as more cost-effective packs of 10 or 25 pieces.

UFCS-R001	1mΩ, bandwidth TBD, <200pH insertion inductance, TBD A maximum pulse current, SMA (F) output, 1pc. Also available as packs: 10pcs **UFCS-R001x10**, 25pcs **UFCS-R001x25**
UFCS-R005	5mΩ, >800MHz bandwidth, <200pH insertion inductance, TBD A maximum pulse current, SMA (F) output, 1pc. Also available as packs: 10pcs **UFCS-R005x10**, 25pcs **UFCS-R005x25**
UFCS-R011	11mΩ, >1GHz bandwidth, <200pH insertion inductance, 104A maximum pulse current @ 100µs, SMA (F) output, 1pc Also available as packs: 10pcs **UFCS-R011x10**, 25pcs **UFCS-R011x25**
UFCS-R024	24mΩ, >1GHz bandwidth, <200pH insertion inductance, 70A maximum pulse current @ 100µs, SMA (F) output, 1pc Also available as packs: 10pcs **UFCS-R024x10**, 25pcs **UFCS-R024x25**
UFCS-R052	52mΩ, >900MHz bandwidth, <200pH insertion inductance, 48A maximum pulse current @ 100µs, SMA (F) output, 1pc Also available as packs: 10pcs **UFCS-R052x10**, 25pcs **UFCS-R052x25**

Step 2: Select Output Connection Accessories

Different output connection accessories are available for either use the shunt as input for optically isolated probes or for direct electrical connection to an oscilloscope because the shunt is no stand-alone measuring instrument.

018-291-970	SMA plug to MMCX socket, 50Ω Adapter for use with FireFly® optically isolated probe series’ input tip cables with integrated 50Ω feed-through.
UFCS-CHOKE **coming soon**	50 Ω impedance matched, common mode choke with a high permeability nanocrystalline core for increasing CMRR (*specs to follow*), preventing issues with unexpected ground loops and common mode noise, SMA (male) in, BNC (male) out, for use with UFCS shunts only
D010031	50 Ω BNC feed-through for 1 MΩ input oscilloscopes, >500MHz