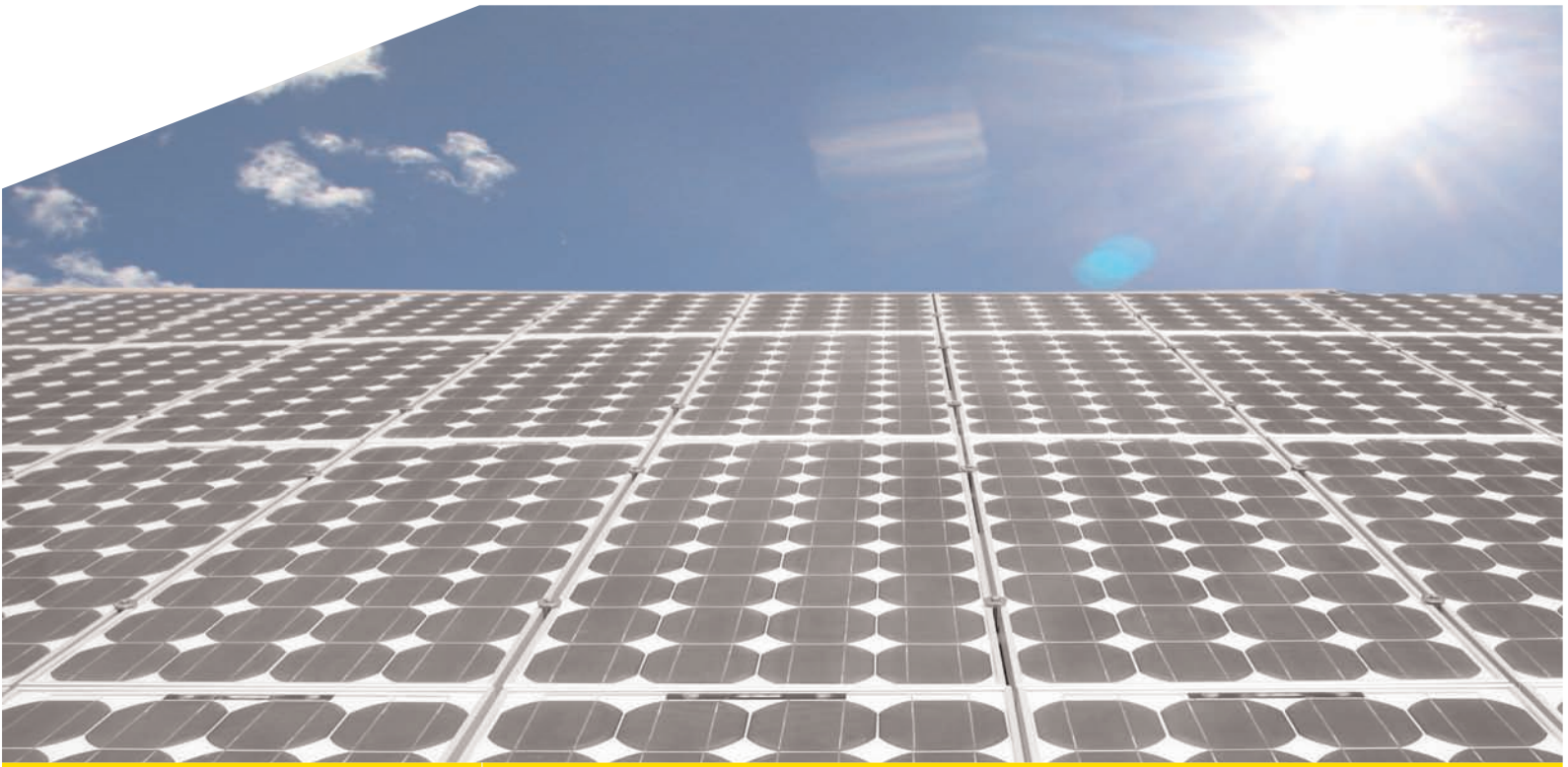


Photovoltaic System Overcurrent Protection

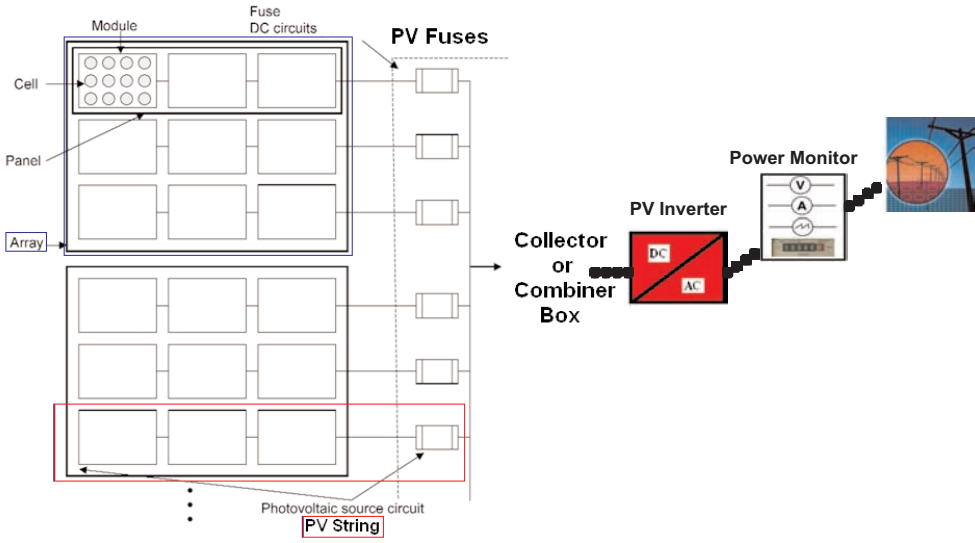
COOPER Bussmann

Introduction

Solar Photovoltaic (PV) systems have, over the last fifty years, evolved into a mature, sustainable and adaptive technology.

This technology is improving as solar cells increase in efficiency and modules attain better aesthetic appearances.

As a result, solar power is gaining more acceptance and is becoming an increasingly cost-effective and clean alternative to the conventional energy sources



- A number of PV panels in series is termed a string
- A number of strings in parallel is termed an array

Photovoltaic Protection System from Cooper Bussmann

As the installations and demand for PV systems increases so does the need for effective electrical protection.

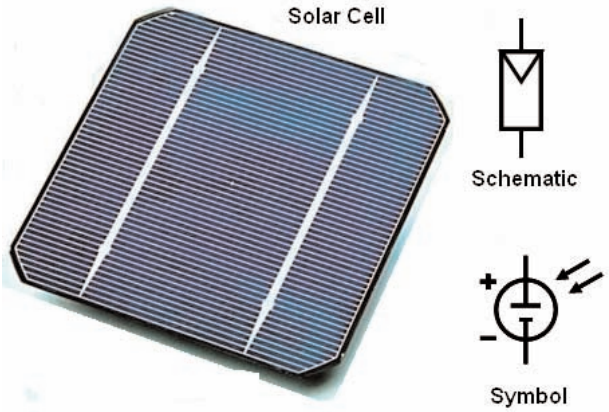
PV systems as with all electrical power systems must have appropriate over-current protection for equipment and conductors.

Cooper Bussmann (the world leader in over-current protection products) has developed a revolutionary new fuse-link for protecting photovoltaic systems.

This development was implemented thru coordinated research and testing with leading Solar Panel/Solar System manufacturers

Photovoltaic System Overcurrent Protection

How do Solar Systems work...



The base Solar Power generation systems are made of Photovoltaic cells and Power inverters. The photovoltaic cells utilise the power of sun light to converters photons to clean DC (Direct Current) electricity.

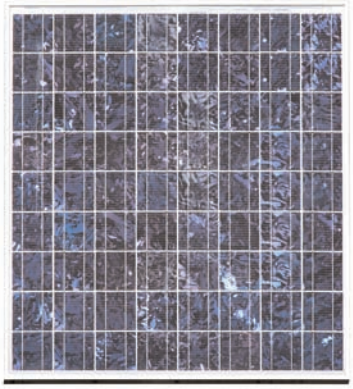
The Electricity generated by the Solar Cells is then fed into a Power Inverter (PV inverter) that converts and regulates the DC source into usable AC power.

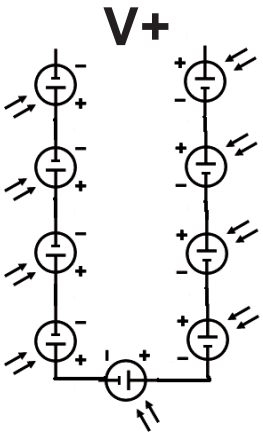
The AC power can then be used locally for specific remote equipment, residential homes or fed directly back into the power grid and used as clean, environmental energy.

Energy Content of Sunlight: Sunlight has an energy content of 1kW (1,000 watts) per square meter.

The typical Solar Panel achieves between 10% and 15% efficiency conversion.

Solar Protection System from Cooper Bussmann





The voltage output of a Solar Panel/Array is defined by the number of individual cells in series. An individual panel (see fig 1) is made up of a series string of photovoltaic cells.

Globally there is a push for utilizing higher voltages (trending to 1000VDC and above).

- A number of PV panels in series is termed a string
- A number of strings in parallel is called an array

The vast majority of large Solar Farms in North America are 600VDC but following the lead from Europe to increase voltages up to 1000VDC to achieve more efficiency

Variations of Solar Panel Output

The most widely used Solar Panels for systems greater than 20kW are the 4", 5" and 6" Poly-crystalline silicon type.

The Silicon type panel can achieve up to approx 7.5A maximum power current per panel. Again there is no specific preference as economics also play a role in the selection of Solar Cell type.

A word of caution is do not assume all 4", 5" and 6" Solar panel designs are equal between different manufacturers. The maximum power out put current of the panels can vary as much as 35% between manufacturers of equal solar cell dimension designs… always select proper conductors/fuses based on the specific Isc* characteristics of the manufacturers specification

*Isc: Short circuit current

Over-Current Protection of PV Systems

The National Electrical Code (NEC) defines the maximum circuit current as 125% of the short circuit current of the PV module (Isc). The conductors and the over-current
protective device are then sized at 125% of the maximum circuit current or 1.56 x Isc. Additionally, International standards such as BS EN7671 Sec 712 for Solar Photovoltaic (PV) Power Supply systems specifies that conductors current carrying ability must be equal to or greater than 1.25 x IscSTC* at any location. The Isc is published by the PV module manufacturers on datasheets. The Isc is typically only 110-115% of the maximum power current (Ipm) of the PV module.

This means that unlike typical grid connected AC systems, the available short circuit current is limited and the over-current protective devices will need to operate effectively on low levels of fault current. For this reason Cooper Bussmann has conducted extensive research and development of fuses that are specifically designed and tested to safely protect PV systems with high DC voltages and low fault currents.

- DCM - 600Vdc
- PV - 1000Vdc

*IscSTC: The Electrical data applies under Standard Test Conditions (STC): Radiation 1,000 W/m² with a spectrum of AM 1.5 and at cell temperature of 25°C

DCM - 600Vdc

PV Fuse - 1000Vdc

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Selecting Fuses for PV String Protection

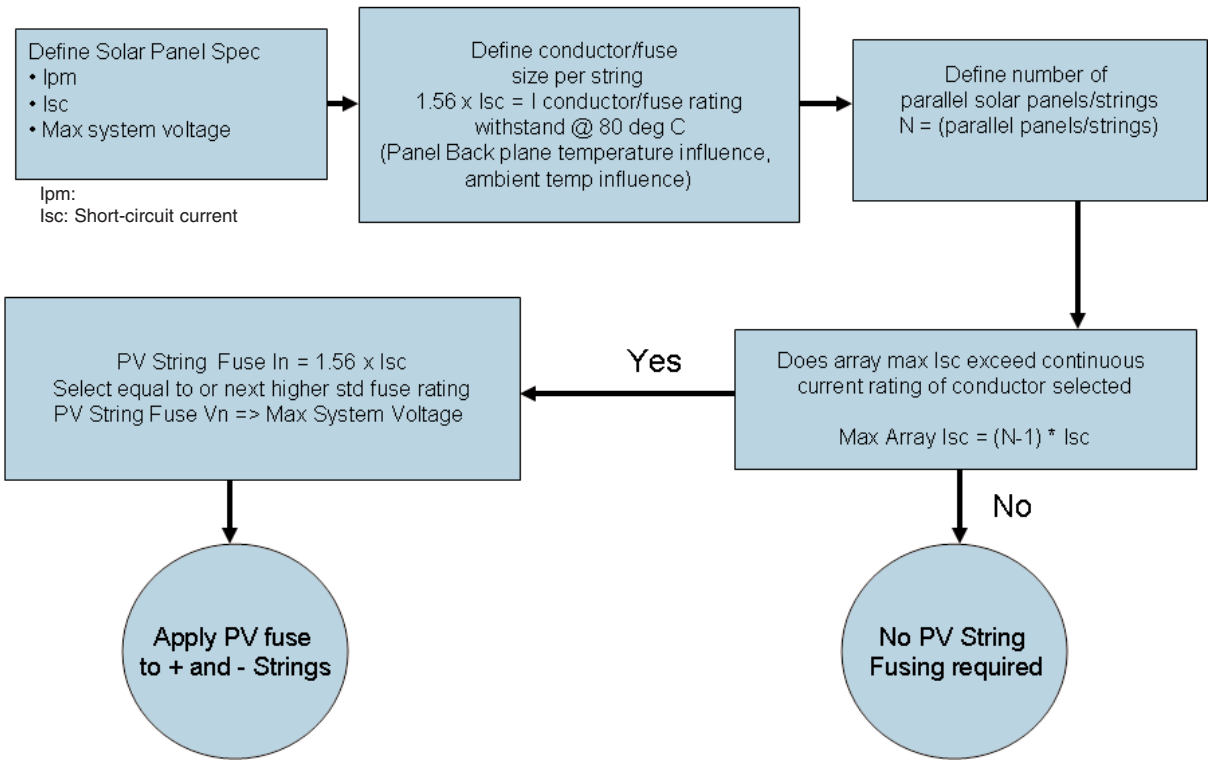
Depending on the desired capacity of the PV system, there may be several PV strings connected in parallel to achieve higher currents and subsequently more power.

PV systems that have three or more strings connected in parallel need to have each string protected (systems that have less than three strings will not generate enough fault current to damage the conductors/equipments and therefore do not present a safety hazard as long as the conductor was sized properly based on local code requirements).

Where three or more strings are connected in parallel a fuse on each string will protect the conductors from damage and eliminate any safety hazards. It will also isolate the faulted string so that the rest of the PV system can continue to generate electricity.

- Protection of Conductors
- Isolate damaged PV modules

PV Fuse Selection Flow-chart



Fuse rating for PV applications

Once it has been determined that maximum short circuit current ((N-1)*Isc) exceeds continuous current rating of conductor, follow the recommendations of selecting the proper PV string fuse

Ex 1: Solar Panel String Fusing

Isc = 5.37A
Ipm = 4.83A
Max System Voltage = 1000VDC(max value of series panels)
Conductor Size Formula = 1.56 * Isc = 1.56 * 5.37 = 8.38A
Conduct Size = 14AWG or 2.5mm^2 = 10.25A @ 80 deg C

N = 4 (4 parallel Solar Panel Strings)
Array Max Isc = (N-1) * Isc = (4-1) * 5.37 = 16.11A
Array Max Isc is greater than conductor withstand
**String fuses required
In = 1.56 x Isc (individual panel only) = 8.37A min fuse rating

Select next higher std rating of 10A: PV-10A10F
Fuse selected will protect selected conductor
Min wire size: 14AWG or 2.5mm^2 = 10.25A @ 80 deg C

Typical Solar Panel Specification

Module Description	
Cell Type	Polycrystalline Silicon
Cell Size	125mm Square (5")
No. of Cells and Connection	72 in Series
Maximum System Voltage	1,000V DC
Electrical Data	
Maximum Power Voltage-(Vpm)	34.6V
Open Circuit Voltage-(Voc)	43.1V
Maximum Power Current-(Ipm)	4.83A
Short Circuit Current-(Isc)	5.37A

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DCM Fuses Technical Data
1/10 - 30A/600Vdc

Description
- Full range of DC Midget in 10x38mm
  AC Maximum Interrupting Rating of 100kA at 600Vac
  DC Maximum Interrupting Rating at 50kA at 600Vdc
  DC Minimum Interrupting Rating of 200% rated current at 600Vdc

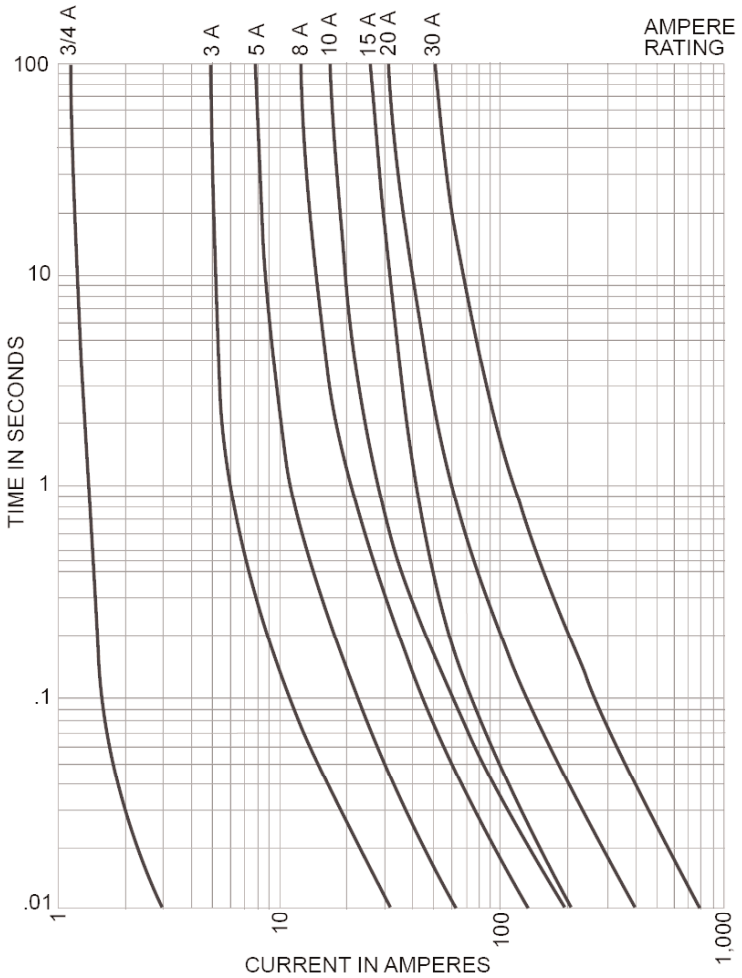
Catalogue Symbol:
- DCM

Class of Operation:
- Fast acting 1/10 to 30A

Fuseholders:
Recommended fuseblocks/fuseholders for 10x38mm fuses:
- Open fuseblocks: BM series, 3743
- Finger safe fuseholders: OPM-NG-SC3, OPM-NG-SM3, OPM-1038, CH series
- Panel-mount fuseholders: HPF series, HPS series, HPG & HPD, HPM series, HPC-D, HPS2 series

Time current-curves:

Time-Current Characteristic Curves–Total Clearing

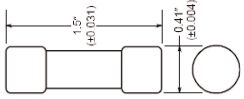


Standards/Approvals
- UL Listed STD 248*14 (File E19180, Guide JDYX)
- CSA Certified C22.2 NO 248.14 (Class 1422-01, File 53787)

Description
- Rated voltage: 600Vdc
  Amps: 1/10 to 30A
  Breaking capacity: 100k at 600Vac
  50k at 600Vdc

Packaging:
- MOQ: 10 Packaging

Dimensions:



PV Fuse-Link Technical Data

Description

- A range of 10x38mm fuse-links specifically designed for protecting photovoltaic strings. These fuse-links are capable of interrupting low overcurrents associated with faulted photovoltaic string arrays (reverse current, multi-array fault).

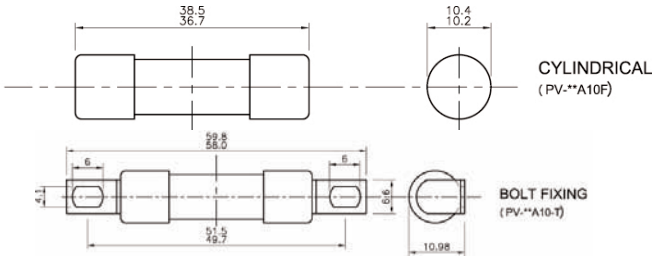
Catalogue Symbol:

- PV-(amp rating)A10F
- PV-(amp rating)A10F-T
- PV-(amp rating)A10F-1P
- PV-(amp rating)A10F-2P

Class of Operation:

- gR - (PV)

Dimensions - mm



Standards/Approvals

- IEC 60269

Description

- Ratings

Volts:	1000Vdc
Amps:	8-15A
Breaking Capacity:	33kA dc
Min Interrupting:	1.3 x I_n

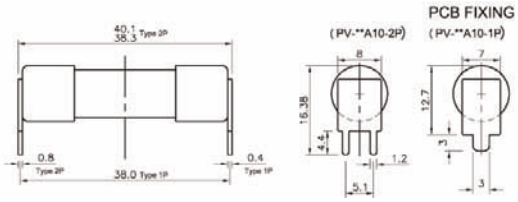
- PV Fuse-Link Coordination with: 4", 5" & 6" solar cells
- Time constant (L/R): Under 1ms

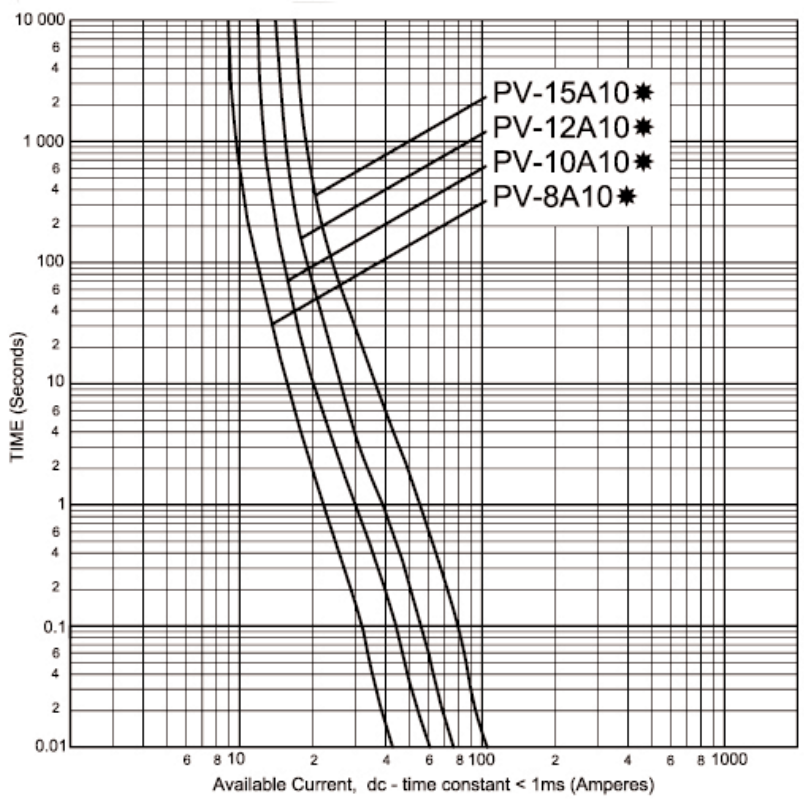
Packaging:

- MOQ: 10 Packaging 100% recyclable

Fuse Holders

- PCB Clip: 1A3400-09
- Modular Fuseholder: CHM1D
- Fuse Block: BM6031 SQ/PQ/B





Fuseholders For PV and DCM Fuse-Links - BM Fuseholders

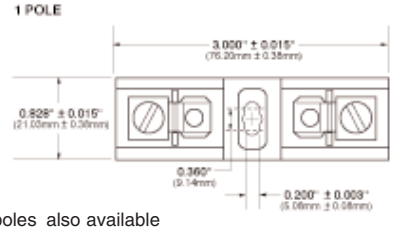
Description
- Type M fuseblock for use with any 10x38 fuses

Catalogue Symbol:
- BM series

DIN Rail Adapters:
- DRA-1 and DRA-2

Standards/Approvals
- UL Recognised, UL 512, Guide IZLT2, File E14853
- CSA Certified C22.2 No 39, Class 6225-01, File 47235

Dimensions - inches



2 and 3 poles also available

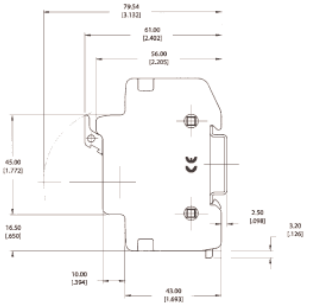
Fuseholders For PV and DCM Fuse-Links - CHM Modular Fuseholders

Description
- The CHM modular fuseholders accommodates 10x38mm fuse-links

Catalogue Symbol:
- CHMD series

Standards/Approvals
- UL Recognised, CSA Certified
- CManufactured in accordance with IEC 60947-3 and IEC 60269

Dimensions - inches

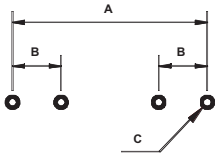


Fuse Clips For PV and DCM - 1A3400 Series

Description
- Fuseclip for 10mm diameter fuses with end stops & straight leads

Catalogue Symbol:
- 1A3400

Footprint - " (mm)



A = 1.625" (41.28mm)
B = 0.405" (10.29mm)
C (4 holes) = 0.091" - 0.095" (2.31 - 2.41)

For board thickness up to 0.125" (3.18)

Dimensions - " (mm)