



# Kraus & Naimer

BLUE LINE switchgear

since 1907



**Guide to the selection  
of AC & DC Switch-Disconnectors  
for Photovoltaic Systems**

**2012**



**The development of the Blue Line rotary switch is based on more than one hundred years experience by Kraus & Naimer in the design and manufacture of electrical switchgear.**

Kraus & Naimer pioneered the introduction of the cam operated rotary switch and continues to be recognized as the world leader in that product field.

Blue Line products are protected by numerous patents throughout the industrial world. They are built to national and international standards and designed to withstand adverse temperatures and climates. Our extensive range includes cam operated rotary switches up to 2400A, main/main emergency-off switch-disconnectors up to 1250A and changeover switches up to 2400A. They can be supplied for mounting on machines, in switch panels or in enclosures using materials such as polycarbonate, GRP, painted mild steel and stainless steel.



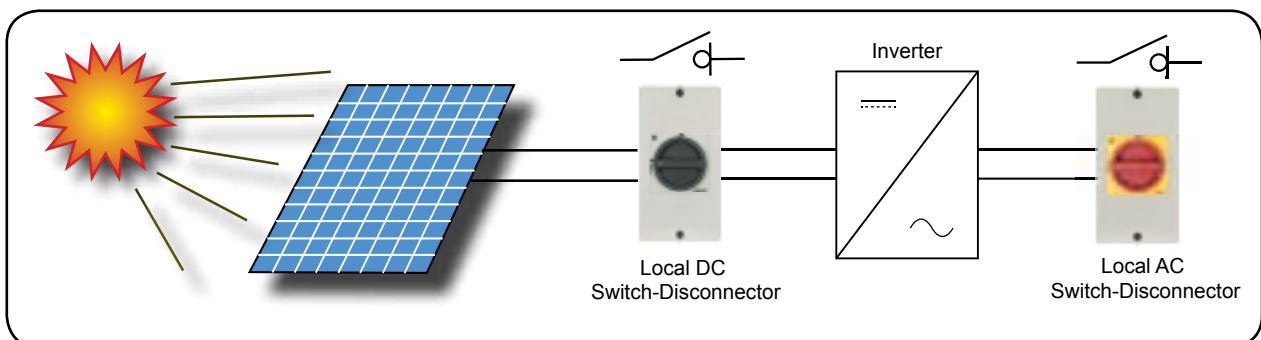
**Kraus & Naimer**

**Kraus & Naimer's Blue Line products are accepted and universally recognised for their quality and workmanship.**

Kraus & Naimer Limited is part of the worldwide Kraus & Naimer Group which celebrated its 100 year anniversary in 2007.

In 1963, Kraus & Naimer Limited was established as the UK sales and marketing company for Kraus & Naimer switchgear. By the early 70's successful growth meant a move to its current purpose-built premises in Newbury, where it supplies over 3,000 customers with world-renowned, high quality Blue Line switchgear products.

A key to our success is the outstanding level of technical product support through our dedicated team of internal and external technical sales engineers. With many years experience, training and unbeatable product knowledge the team can find a suitable solution for most switch applications.





## AC & DC switch-disconnectors for photovoltaic systems

At Kraus & Naimer our extensive experience in the design and manufacture of electrical switchgear ensures we are able to help installers, wholesalers, training centres and design engineers with the correct selection of our products in relation to their applications.

There is a distinct need for information on the selection of AC & DC switch-disconnectors for photovoltaic systems. For customers who are new to the PV market, the equipment used in the systems and particularly the challenge of working with DC can be confusing.

We hope this guide will be welcomed and encourage any queries with regard to the selection of switch-disconnectors. Questions can be made direct to our experienced sales team or our technical department.

### What you will find in this guide:

1. An explanation of switch-disconnectors
2. Information on relevant standards and guides
3. An explanation of utilisation categories
4. AC switch-disconnector selection criteria
5. DC switch-disconnector selection criteria
6. Example systems & further DC information
7. Current selection charts & price lists
8. Product data & connection diagrams





## Switch-Disconnectors

The requirements for switch-disconnectors for use on electrical installations within the UK are specified by BS 7671:2008+A1, IET Wiring Regulations. The requirements for isolation and switching are contained in Chapter 53, Section 537; plus specific information relating to PV systems; which is given in section 712.

Kraus & Naimer's switch-disconnectors are designed and manufactured in accordance with the requirements of BS EN 60947-3; which is listed in table 53.4 of BS 7671 as being an appropriate standard for isolation.

***It is important to note that the use of switches for safety isolation (i.e. not designated as a disconnector or switch-disconnector) is contrary to BS 7671 and hence the EU's low voltage directive. Therefore only a device designated as a disconnector or switch-disconnector can be used for the purpose of safety isolation of an electrical circuit.***

BS EN 60947-3 is the relevant standard for manually operated industrial switch products. The standard defines the following product types;

### a) Switch

A device capable of making, carrying and breaking current within an electrical circuit under defined conditions.

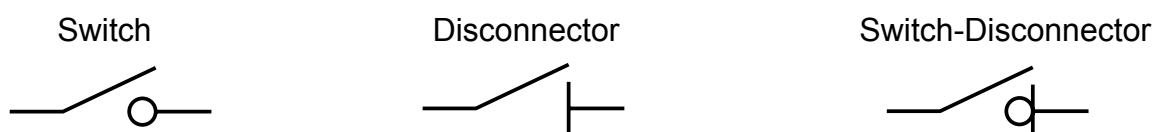
### b) Disconnector

A device capable of carrying current within an electrical circuit and providing off-load isolation within that circuit in accordance with the specified requirements for safety isolation.

### c) Switch-Disconnector

A device capable of complying with the requirements for both Switch and Disconnector devices; i.e. provides on-load isolation and operational switching.

In stating a product's compliance with BS EN 60947-3, the manufacturer must state the product type that applies and the product must be clearly marked with the designated symbol for the appropriate product type. The appropriate symbols are below.



### Other relevant PV guides/standards

- DTI publication "Guide to the installation of PV systems" - 2nd edition
- "Guide to the installation of PV systems" - 3rd edition, IN DRAFT
- IEC 62548 edition 1: Design requirements for photovoltaic (PV) arrays, IN DRAFT
- BS EN 62446 - Grid connected photovoltaic systems. Minimum requirements for system documentation, commissioning tests and inspection.
- IEC 62257-7-1 edition 2 - Recommendations for small renewable energy and hybrid systems for rural electrification, part 7-1: Generators - Photovoltaic generators.
- IEC 60364-7-712 edition 1 - Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems

## Utilisation Categories

Utilisation categories simplify the selection of devices. Examples of utilisation categories for low voltage switchgear and controlgear together with the relevant product standards are given in BS EN 60947-1, Annex A. It is the characteristics of the load to be switched and its application that determine the required rating of the switchgear. Utilisation categories take into account the intended applications and the associated rating of the switchgear which prevents customers being confused by technical details.

Manufacturer's technical data provides rated operational currents/powers for various rated operational voltages and utilisation categories. This helps users and design engineers in the selection of the correct switchgear.

The rated operational current, voltage and utilisation category determine the suitability of a device for its intended application, one device may have a rating for a variety of different utilisation categories.

Utilisation categories typically used in PV systems are;

AC AC-21 - Switching of resistive loads, including moderate overloads  
AC-22 - Switching of mixed resistive and inductive loads, including moderate overloads

DC DC-21 - Switching of resistive loads, including moderate overloads  
DC-22 - Switching of mixed resistive and inductive loads, including moderate overloads

The designation of some utilisation categories are completed by the suffix A or B according to whether the intended application requires frequent or infrequent operations.

Utilisation categories with the suffix B are appropriate for devices which, due to design or application, are only intended for infrequent operation. This could apply, for example, to switch-disconnectors normally only operated to provide isolation for maintenance work.

When stating product compliance with BS EN 60947-3 for a given utilisation category there are a number of mandatory tests which need be completed, one of these tests in BS EN 60947 parts 1 & 3 is the 'Operational Performance test', below is some extracted data from section 7.2.4.2 of BS EN 60947-3.

The below tests are required as a minimum for compliance with the standard.

Verification of operational performance for rated operational current of 0 - 100A

Utilisation Category	Number of test operations		
	without current	with current	Total
DC-22A	8500	1500	10,000
DC-22B	1700	300	2000
DC-21A	8500	1500	10,000
DC-21B	1700	300	2000

## AC Switch-Disconnecter Selection Criteria

The method of selection is mainly based on general engineering practice with some additional factors applicable to grid connected PV systems. For the AC switch-disconnector the public supply should be considered the source and the PV installation the load.

In grid connected PV systems a **Lockable** switch-disconnector must be located in an accessible position in the premises, for example adjacent to the consumer unit. Typically if the switch-disconnector and inverter are not in the same location, then an additional local switch-disconnector should be installed adjacent to the inverter (this is to facilitate maintenance of the AC cable run and inverter).

Switch-disconnectors complying with BS EN 60947-3 are appropriate for use in PV systems as specified in BS 7671, for further details see the standard.

Principle factors to be considered when selecting the AC switch-disconnector.

### 1. Number of poles

2 Pole - Single phase, typically for domestic installations.

4 Pole - Three phase + neutral, typically for larger commercial installations.

### 2. Rated voltage & current

Voltage & current - based on the output of the inverter, these figures are typically given as per phase (line to neutral) values in the inverter datasheets i.e. for a three phase inverter they may give 16A at 230V. For three phase output the switch must be suitably rated for the line to line voltage, typically 415V.

### 3. Correct Utilisation category - typically AC-21A or AC-22A

### 4. The ambient temperature where the switch-disconnector is to be installed

Industrial enclosed AC switch-disconnectors are normally rated for use in an environment with an ambient temperature of 35°C, which will be fine for most installations. If the switch-disconnector is installed in an area where ambient temperatures are higher, such as a loft space, then a switch-disconnector capable of handling ambient temperatures of 50°C may be required (most inverters are suitably rated for use in environments with an ambient temperature of 50°C).

### 5. Cable size

The switch terminal capacity must be suitable for the size of cable and type of termination used. Our catalogues detail this information or see page 15 of this guide. Required cable size is determined by the rated load current, volt-drop, ambient temperature and type of cable being used. However, on PV installations, the size of the cable is frequently determined by the inverter requirements. This is due to the fact that most grid connected inverters have set parameters on grid impedance of the AC cable. Many inverter companies will include a table in their installation or technical manuals which gives information on the size of cable and the maximum length to suit their requirements.

### 6. Short circuit & overload protection device

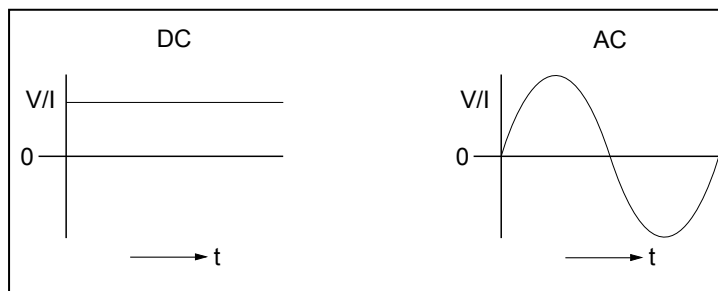
Fuse or circuit breaker protection must be provided at connection to the consumer unit. The maximum back-up fuse rating for Kraus & Naimer switches is shown in the table below. The actual rating of the fuse/circuit breaker will normally be lower, with the value being determined by the cable or inverter requirement.

Switch Type	Short Circuit Protection
KG20	35A
KG32	35A
KG41	50A

*The list of above mentioned factors is not in anyway to be viewed as an exhaustive list, selection criteria will vary from installation to installation.*

## DC Switch-Disconnecter Selection Criteria

DC is inherently more difficult to interrupt than AC. Alternating current passes the zero point twice each cycle. Direct current is constant and will not drop to zero unless the supply is disconnected.



When breaking DC under load an arc is created, once there is enough resistance built up the arc will break. It is vital to break the arc quickly. There are a number of ways to achieve this and one common method used is the series connection of contacts. This will increase the air gap and stretch and suppress the arc without damaging the contacts. This method improves switching capacity, contact life and allows higher operating voltages.

It is a requirement of BS 7671 that a switch-disconnector shall be provided on the DC side of a PV installation, the standard for switch-disconnectors is BS EN 60947-3.

Principle factors to be considered when selecting the DC switch-disconnector.

### 1. Number of strings to be isolated

2 Pole - Single string, 4 Pole - Two string, etc.

It is considered good practice to use 1 isolator per string. However, 2 string isolators are available.

### 2. Rated current & voltage

Voltage calculations: The rated operational voltage of the switch should be equal to or greater than the product of open circuit voltages ( $V_{oc}$ ) and correction factors as per current standards e.g. total of series connected PV panels x  $V_{oc}$  of an individual panel x correction factor (1.15).

Current calculations: The rated operational current of the switch should be equal to or greater than the product of short circuit currents ( $I_{sc}$ ) and correction factors as per current standards e.g. total of parallel connected PV strings x  $I_{sc}$  of an individual panel x correction factor (1.25).

### 3. Correct Utilisation category - typically DC-21B, but DC-21A, DC-22/A or B can be used.

### 4. The ambient temperature where the switch-disconnector is to be installed

If the switch-disconnector is installed in an area where ambient temperatures are higher, i.e. a loft space, then a switch-disconnector capable of handling ambient temperatures of 50°C may be required (most inverters are suitably rated for use in environments with an ambient temperature of 50°C). All of our DC enclosed range are rated for use at 50°C.

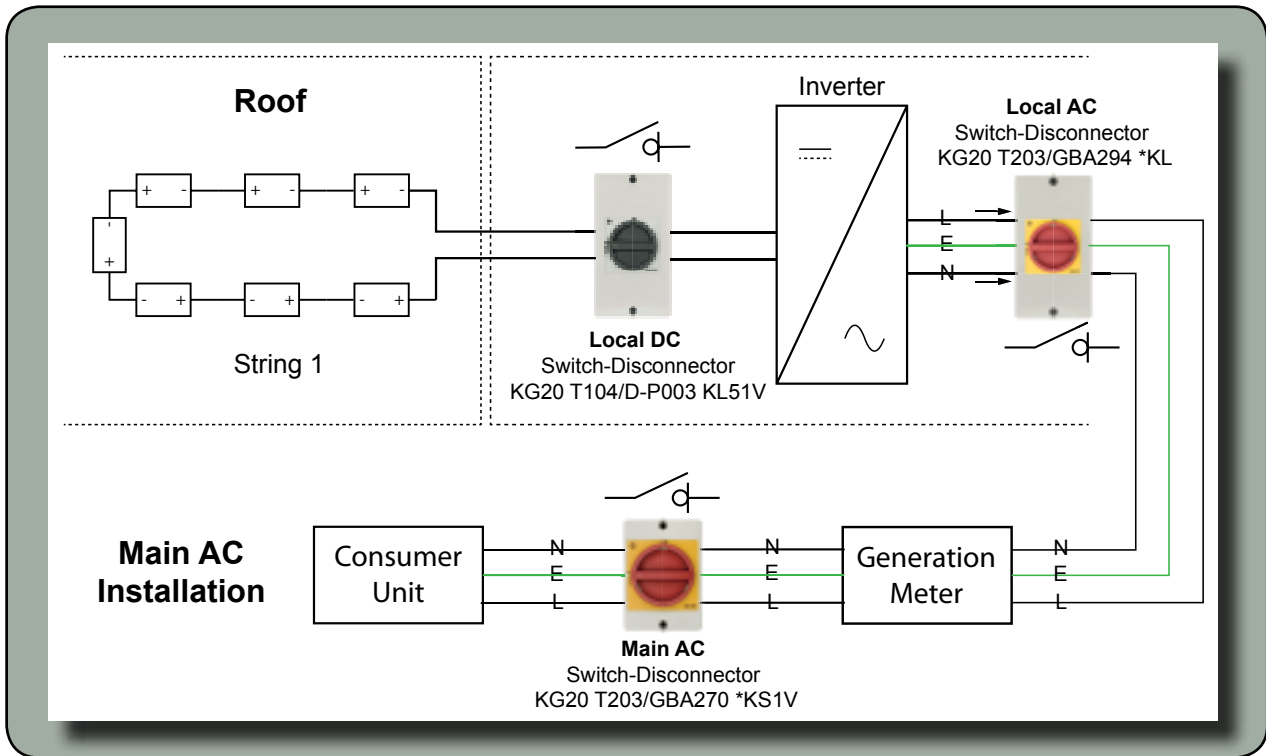
### 5. Cable size

The switch terminal capacity must be suitable for the size of cable and type of termination used. Our catalogues detail this information or see page 15 of this guide.

Required cable size is determined by the rated load current (base on calculation in point 2 above), volt-drop, ambient temperature and type of cable being used (normally double insulated).

*The list of above mentioned factors is not in anyway to be viewed as an exhaustive list, selection criteria will vary from installation to installation.*

## Example Systems - typical 3kW system



Typical Installation Data		
Type	AC	DC
Max Voc Inverter input	N/A	550V
Max Isc Inverter input	N/A	17A
Max Inverter output (A)	16A	N/A
Cable size used	4mm <sup>2</sup>	2.5mm <sup>2</sup>
Max Ambient temp at local isolator location	50°C	50°C
Max Ambient temp at main isolator location	35°C	N/A
Circuit Protection	20A	N/A
Solar Panel Data		
Maximum Power Rating	235Wp	
Number of panels	12	
Voc of individual panel	37V	
Isc of individual panel	8.6A	

Correction Factors	
For Voltage, Voc	1.15
For Current, Isc	1.25

### AC Selection

Local = KG20 T203/GBA294 \*KL  
 Main = KG20 T203/GBA270 \*KS1V  
 (AC switches selected from page 12)

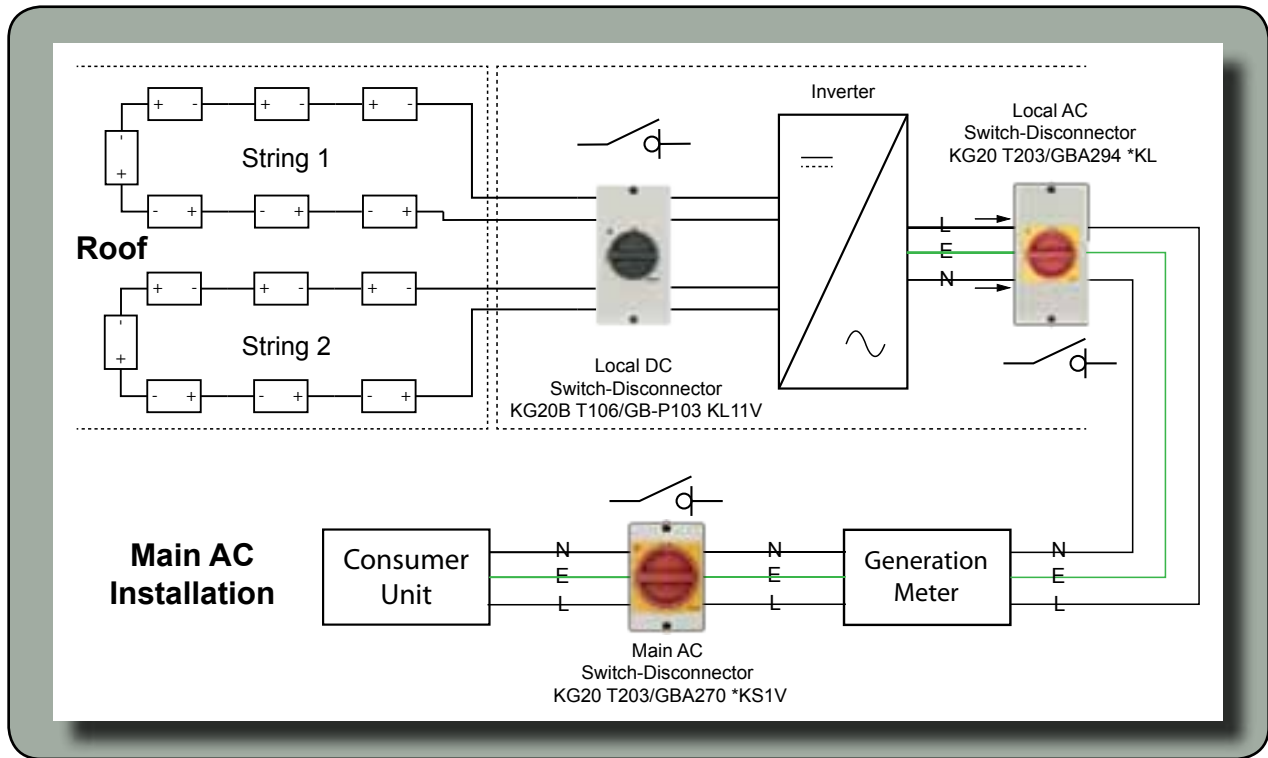
### DC Selection Ratings

Voltage =  $12 \times 37V \times 1.15 = 510.6V$   
 Current =  $8.6A \times 1.25 = 10.75A$

Therefore the **KG20 T104/D-P003 KL51V** is suitably rated 20A at 650V, DC-21B.  
 (DC switch selected from page 13)



## Example Systems - typical 5kW system



Typical Installation Data		
Type	AC	DC
Max Voc Inverter input	N/A	550V Per string
Max Isc Inverter input	N/A	15A Per string
Max Inverter output (A)	22A	N/A
Cable size used	6mm <sup>2</sup>	4mm <sup>2</sup>
Max Ambient temp at local isolator location	50°C	50°C
Max Ambient temp at main isolator location	35°C	N/A
Circuit Protection	25A	N/A
Solar Panel Data		
Maximum Power Rating	235Wp	
Number of panels in each string	12	
Voc of individual panel	37V	
Isc of individual panel	8.6A	

Correction Factors	
For Voltage, Voc	1.15
For Current, Isc	1.25

### AC Selection

Local = KG20 T203/GBA294 \*KL  
 Main = KG20 T203/GBA270 \*KS1V  
 (AC switches selected from page 12)

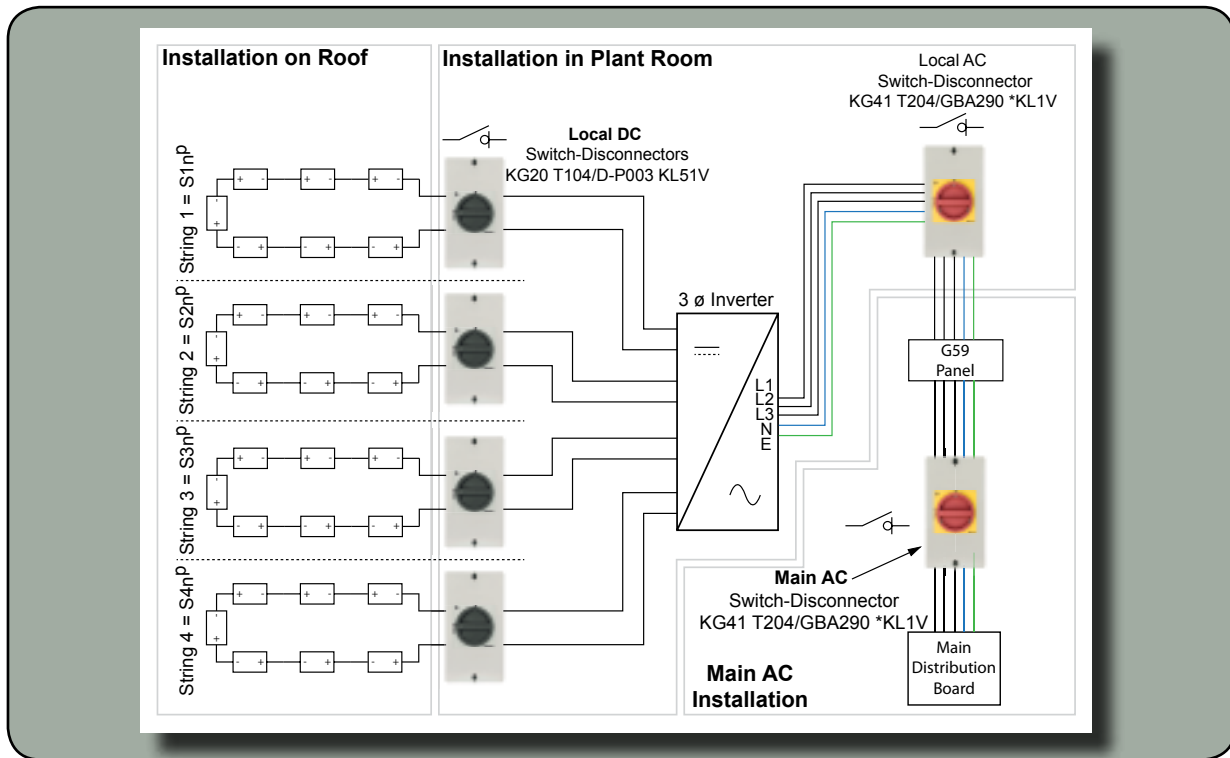
### DC Selection Ratings - per string

Voltage =  $12 \times 37V \times 1.15 = 510.6V$

Current =  $8.6A \times 1.25 = 10.75A$

Therefore the **KG20B T106/GB-P103 KL11V** is suitably rated 18A at 600V, DC-21B - per string.  
 (DC switch selected from page 14)

# Example Systems - typical 15kW system



Typical Installation Data		
Type	AC	DC
Max Voc Inverter input	N/A	1000V
Max Isc Inverter input	N/A	Input A = 33A Input B = 11A
Max Inverter output (A)	24A	N/A
Cable size used	10mm <sup>2</sup>	6mm <sup>2</sup>
Max Ambient temp at local isolator location	50°C	50°C
Max Ambient temp at main isolator location	35°C	N/A
Circuit Protection	32A	N/A
Solar Panel Data		
Maximum Power Rating	235Wp	
Number of panels in each string	Input A = 17 Input B = 14	
Voc of individual panel	37V	
Isc of individual panel	8.6A	

Correction Factors	
For Voltage, Voc	1.15
For Current, Isc	1.25

## AC Selection

P/room = KG41 T204/GBA290 \*KL1V  
Main = KG41 T204/GBA290 \*KL1V

KG41 has to be used only due to cable size on AC side of installation.  
(AC switches selected from page 12)

## DC Selection Ratings

Panel setup = 3 strings to input A & 1 string to Input B.  
1 isolator per string required.

Voltage = A = 17 x 37V x 1.15 = 723.4V  
B = 14 x 37V x 1.15 = 595.7V

Current = 8.6A x 1.25 = 10.75A

Therefore the **KG20 T104/D-P003 KL51V** is suitably rated 18A at 800V, DC-21B.  
(DC switch selected from page 13)

# DC Voltage & Current in PV Systems

## DC Voltages in PV systems:

DC Voltage in PV systems is determined by the solar panel output and how the MPPT controls it. Voltage values for the DC isolator selection is based on the Voc multiplied by a correction factor (generally a 1.15 multiplication in the UK) as outlined in current standards / guidance documents.

At present the ceiling value for PV systems is 1000V DC, this is the maximum voltage given by solar panel and inverter manufacturers alike. Typically you will find a statement like “the following limiting values at the DC input of the inverter may not be exceeded” or “the maximum open circuit voltage (Voc), which can occur at a cell temperature of -10°C, may not exceed the maximum input voltage of 1000V”.

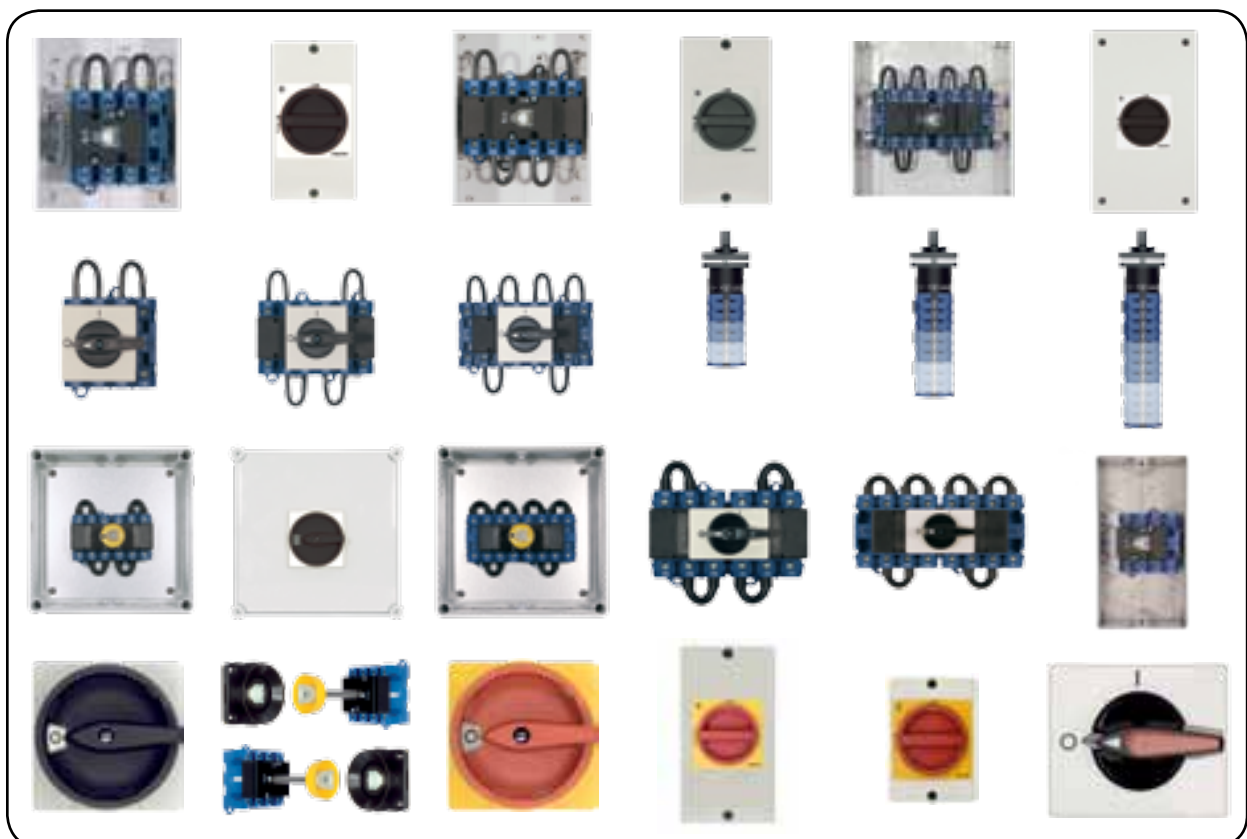
## DC Currents in PV systems:

DC Current in PV systems is determined by the solar panel output and how the MPPT controls it. Current values for the DC isolator selection is based upon the Isc of the panel multiplied by the number of panels or strings there are in parallel and including a correction factor (generally a 1.25 multiplication) as outlined in current standards / guidance documents.

Most solar panels used in the UK have a Isc of between 5A & 9A Isc so typically when a customer is asking for an isolator to isolate 1 series connected string the current should be no more than 11.25A.

If a client were to ask for a DC isolator to isolate 2 strings connected in parallel then it would be nearer 22.5A and so on.

## Product Range



# AC Switch Disconnectors for *Photovoltaic*



Switch - Disconnectors, 3 & 4 pole

- IP66/67 Protection
- Red/Yellow Padlockable Handle
- Grey Insulated Enclosure
- Switch Interlocked with lid to prevent opening in "ON" position
- Earth Terminal

## AC Switch Disconnectors - Single Phase

Current Rating AC-21A (per contact)	Order Code	Fig. <sup>2)</sup>	Price
25A	KG20 T203/GBA270*KS1V	5	£23.16
25A	KG20 T203/GBA294*KL <sup>1)</sup>	1	£28.10
32A	KG32 T203/GBA294*KL <sup>1)</sup>	1	£31.92
40A	KG41 T203/GBA270*KL1V	2	£40.93

## AC Switch Disconnectors - Three Phase

Current Rating AC-21A (per contact)	Order Code	Fig. <sup>2)</sup>	Price
25A	KG20 T204/GBA290*KS1V	5	£28.62
25A	KG20 T204/GBA486 KL51V <sup>1)</sup>	1	£34.67
32A	KG32 T204/GBA486 KL51V <sup>1)</sup>	1	£40.45
40A	KG41 T204/GBA290*KL1V	2	£45.84

<sup>1)</sup> Larger enclosure to match KG20/32 T104 DC enclosure

<sup>2)</sup> For dimensions see page 15

# DC Switch Disconnectors for *Photovoltaic*

Switch - Disconnectors, 2 pole - for single string

- IP66/67 Protection
- Black/Grey Padlockable Handle
- Class II compliant, Grey Insulated Enclosure
- Switch Interlocked with lid to prevent opening in "ON" position
- Rated for use in ambient temperatures of 50°C



## DC Switch Disconnectors - Selection Chart DC21B

450V	500V	650V	800V	920V	1000V	Order Code	Fig. <sup>1)</sup>	Price
25A	21A	20A	18A	11A		KG20 T104/D-P003 KL51V	1	£38.58
28A	28A	25A	23A	15A	12A	KG32 T104/D-P003 KL51V	1	£43.92
40A						KG41 T104/D-P003 KL11V	2	£55.47
			21A		20A	KG20B T106/D-P003 KL11V	2	£56.60
					25A	KG32B T106/D-P003 KL11V	2	£65.04
		40A	28A			KG41B T106/D-P003 KL11V	3	£90.23
			25A			KG20B T108/D-P003 KL11V	3	£86.01
					26A	KG32B T108/D-P003 KL11V	3	£96.70
				40A	35A	KG41B T108/D-P003 KL11V	3	£108.25
		60A				KG80C T106/D-P003 STM	4	£268.64
			60A			KG80C T108/D-P003 STM	4	£294.55

Please select the correct switch-disconnector according to the maximum voltage and current output of all upstream PV modules, this must include all corrective factors according to relevant standards.

<sup>1)</sup> For dimensions see page 15



# DC Switch Disconnectors for *Photovoltaic*

Switch - Disconnectors, 4 pole - for 2 string

- IP66/67 Protection
- Black/Grey Padlockable Handle
- Class II compliant, Grey Insulated Enclosure
- Switch Interlocked with lid to prevent opening in "ON" position
- Rated for use in ambient temperatures of 50°C



## DC Switch-Disconnectors - Selection Chart DC-21B

Ratings Per String						Order Code	Fig. <sup>1)</sup>	Price
220V	280V	340V	400V	460V	500V			
25A	21A	20A	18A	11A		KG20 T104/GB-P103 KL51V	1	£38.58
28A	28A	25A	23A	15A	12A	KG32 T104/GB-P103 KL51V	1	£43.92
40A						KG41 T104/GB-P103 KL11V	2	£55.47
Ratings Per String						Order Code	Fig. <sup>1)</sup>	Price
330V	420V	510V	600V	690V	750V			
25A	21A	20A	18A	11A		KG20B T106/GB-P103 KL11V	2	£56.60
27A	27A	25A	23A	15A	12A	KG32B T106/GB-P103 KL11V	2	£65.04
40A	28A					KG41B T106/GB-P103 KL11V	3	£90.23
Ratings Per String						Order Code	Fig. <sup>1)</sup>	Price
440V	560V	680V	800V	920V	1000V			
25A	21A	20A	18A	11A		KG20B T108/GB-P103 KL11V	3	£86.01
26A	26A	25A	23A	15A	12A	KG32B T108/GB-P103 KL11V	3	£96.70
40A	28A					KG41B T108/GB-P103 KL11V	3	£108.25

Please select the correct switch-disconnector according to the maximum voltage and current output of all upstream PV modules, this must include all corrective factors according to relevant standards.

<sup>1)</sup> For dimensions see page 15

# Product Data & Connection Diagrams

Terminal Capacity / Tightening Torque for Terminal Screws / Cable Stripping Length				
Switch Type	Terminal Capacity		Tightening Torque for Terminal Screws	Cable Stripping Length
	Single core / Stranded wire	Flexible wire, with sleeve		
KG20 / KG32	6mm <sup>2</sup>	4mm <sup>2</sup>	1.25Nm	9mm
KG41 / KG64	16mm <sup>2</sup>	10mm <sup>2</sup>	1.80Nm	10mm
KG80C	50mm <sup>2</sup>	35mm <sup>2</sup>	3.00Nm	14mm

Connection Diagrams

AC

Single String

Two String

T203



T204



AC

Single String

Two String

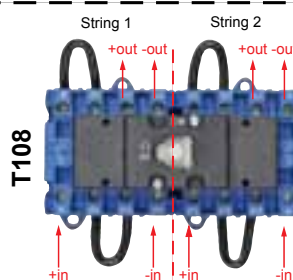
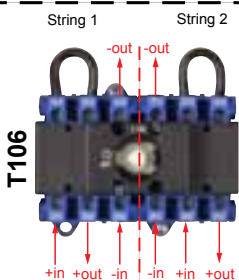
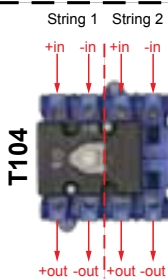
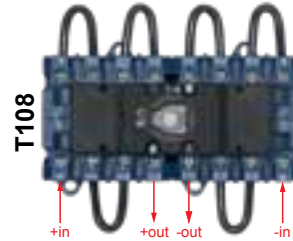
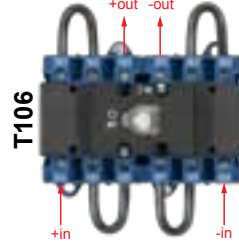
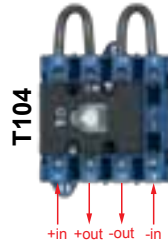


FIG. 1

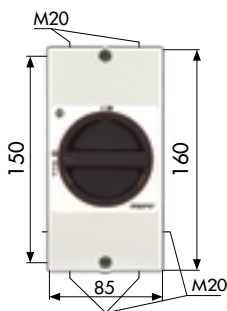


FIG. 2

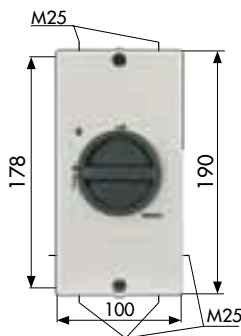


FIG. 3

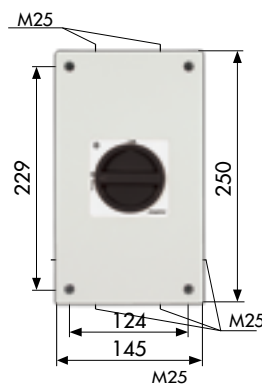


FIG. 4

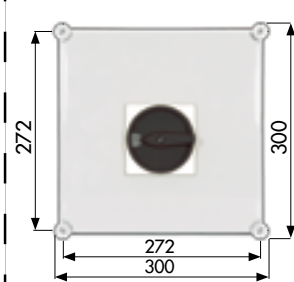
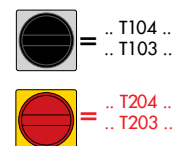
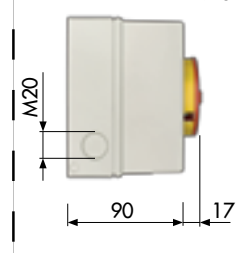
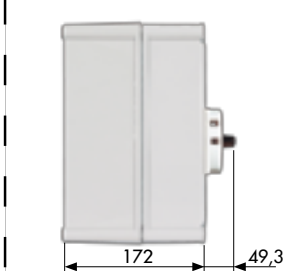
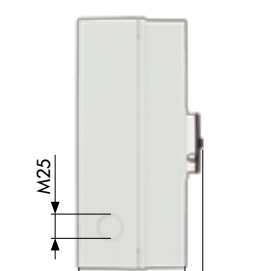
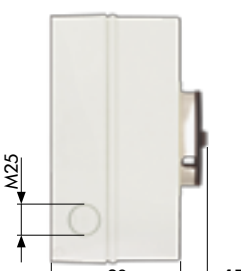
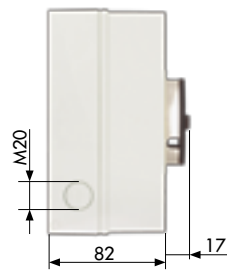
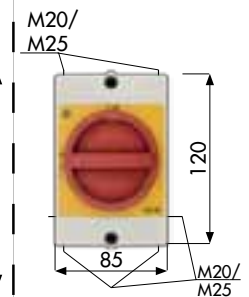


FIG. 5





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