BPV 020 - 090
BPM-M/T 020M - 090M/T
BPH 020 - 090

Technical Specification

Solid-State
Ground Power Unit

www.bgsegroup.com | sales@bgsegroup.com

Table of Contents

1 General Description

The BPV (B-Power solid-state frequency converter) is an excellent choice for a 400 Hz solid-state ground power unit. The unit has a compact design for easy operation and is comfortably to maintain. Due to the high-quality output voltage, the BPV can supply all common aircraft including B787 and A350.

In comparison to other known solid-state GPU models, B-Power relies on power electronics by using inverter modules called DIM for 400 Hz conversion. The Dynamic Inverter Module (DIM) is a bidirectional 3-phase inverter module designed based on the latest semiconductor technology. It is an inverter with power flow in both directions, the DIM is used for rectifying the mains voltage as well as inverting into 400 Hz voltage (back to back operation). Therefore, the hardware of the rectifier (PFC – power factor correction) and inverter (DC/AC) is the same.

The firmware is automatically switching via the CAN address that the module receives from the plug-in system on the rear of the module. No address configuration is required – only Plug & Play principle. Due to the high-power density, each module has approximately 5 kg, the entire active part at 90 kVA output power only weighs around 40 kg.

The modules can be easily exchanged via a Plug & Play plug-in system. As modules of the same function are operated in parallel, there are numerous advantages like redundancy, an increase in the overall efficiency of the unit in the partial-load operating range, extremely low MTTR (Mean Time To Repair) value due to the easily exchangeable plug-in system and lower spare part cost for a DIM.

The unit is designed according to the known valid specifications which are further mentioned below in the technical data.

Ground power – built to perform.

BPH + BCH 180 mounted on PBB

2 Customer Benefits

2.1 Efficiency at its best

The solid-state ground power unit combines a robust design with the latest inverter technology and cuts down lifecycle costs to a minimum due to highest efficiency. The modular design of all major electrical/electronic components guarantees highest output quality and reduces the mean time to repair to a minimum (<10 min). The solid-state ground power unit is made of fully recyclable materials and therefore presents a sustainable possibility to provide electricity to aircrafts.

2.2 Plug & Play Design

An innovative Plug & Play concept is applied to all electrical and mechanical components in order to allow an easy and fast installation or change out of spare parts with best accessibility. By this new design, the amount of electrical wiring could be reduced to a minimum to guarantee a fail-safe operation and ensure maximum reliability.

2.3 Modular Power Module DIM - Dynamic Inverter Module

Beside highest efficiency of up to 94%, achieved by using the latest semiconductor technology, a modular power concept was key for the new innovative B-Power solid-state ground power unit. Each DIM module has a rated power of 22.5kVA. No matter if it´s an input or output module , it can be easily exchanged among each other and in case one DIM fails , real redundancy among the other modules can be guaranteed.

2.4 Intuitive User Interface

The newly designed 7” user interface is reduced to the very essentials. Due to its clearly arranged design, it is intuitively to use for the operator and service staff. Different applications such as a bridge mounted cable coil or even PCA unit can be easily implemented. Having only one intuitive user interface makes ground support life easier

2.5 Internet of Things (IOT)

Service support is indispensable nowadays – a 3G module is implemented as standard to provide remote access to all units and increase the overall service level to our customers. A smart glass option for real-life remote assistance can additionally enhance the support at site. Predictive maintenance will further increase the units’ availability by not only monitoring partial load sharing among the DIMs, also considering the lifetime of electrical components.

ADVANTAGES

- Compact and modular design
- Latest Inverter Technology
- Innovative power module design for redundant operation
- Active power factor correction (PFC)
- Lowest MTTR (Mean Time To Repair) value (<10min)
- Plug & Play concept – Easy service and maintenance
- Highest overall efficiency in the full-load and partial-load range
- Latest circuit board design incl. IoT (Internet of Things) as standard
- Comfortably combinable with all connection systems
- Fully recyclable materials
- Easy and intuitive 7” user interface
- Smart Services Support as add-on

3 Technical Data

3.1 General Data

	BPV, BPM 020 - 090, Solid-State Ground Power Unit	
Input		
Frequency	50 / 60 ± 5 %	Hz
Voltage	3 x 380 ± 10 % 3 x 480 ± 10 % other voltage levels on request	V V
Power Factor	0.99 through PFC (power factor correction)	
Current distortion	< 4 %	
Inrush current	None (< I nominal)	
Output		
Nominal output	22.5 / 45 / 67.5 / 90 112.5 / 135 / 157.5 / 180	kVA kVA
Voltage	3 x 200 / 115	VAC
Frequency	400	Hz
Efficiency	> 94	%
Load power factor	0.6 lagging / inductive to 0.95 leading / capacitive	
Static voltage regulation	< 0.5	%
Crest factor	1.414 ± 3	%
Phase angle symmetry	120° ± 1° for balanced load 120° ± 2° for 30% unbalanced load	
Total harmonic content	< 2	%
Protection		
Protection class	Standard IP55 Optional IP66	
Input/Output	Short circuit protection Over and under voltage protection Overload protection	
General	No break power transfer Over-temperature protection	
Overload		
Overloads	125 % for 10 min. 150 % for 1 min. 200 % for 30 sec. 300 % for 10 sec. 400 % for 1 sec.	

Ambient conditions		
Operating temperature	-30 to +52 other temperatures on request	°C
Humidity	Up to 99	%
Noise level at 1 m	< 65	dB (A)
Products		
Mean-time to repair	< 10 min.	
Materials	Aluminium/Stainless Steel and PC UV for highest corrosion resistance – fully recyclable	
Access	Easy access for maintenance and repair	
Options		
Optional	Remote maintenance and telematics	
	Modbus TCP/IP connection	
	Military interlock	
	User management integrated in the HMI	
	Leakage current supervision	
	90% interlock	
	BMS integration	
	Neutral voltage supervision	
	Broken neutral supervision	
	Protective isolation acc. DFS 400 (4 kV)	
Versions		
Types of installation	Floor-mounted (BPV 020-180)	
	Bridge-mounted (BPH 020-090)	
	Mobile Moveable (BPM 020-090-M)	
	Mobile Towable (BPM 020-090-T)	
	Mobile Towable (BPM 110-180-T)	
Connection Systems		
Cable Coil	Floor-mounted	
	Bridge-mounted	
Pit Systems	Hatch Pit	
	Pop-up Pit	
Cable carriers	for up to three outputs	

Standards	
	ISO 6858:2017
	EN 2282
	BS 2G 219
	EN 1915-1&2
	DFS 400
	MIL-STD-704F
	SAE ARP 5015
	EN 61000-6-2
	EN 61000-6-4
	EN 12312-20

Weight		
BPV 090	~230	kg
BPV 045	~210	kg
BPM 090-T+DDCM (28VDC) incl. 10m cable	~635	kg
BPM 045-T+DDCM (28VDC) incl. 10m cable	~600	kg
BPH 090 + BCH 090	~750	kg

3.2 Main characteristics

- Designed for a large input voltage range of 3 x 380 V to 3 x 480 V
- Input current distortion < 4 %
- Overall efficiency > 94 %
- Operating temperature up to 60°C (140°F) at aircraft load possible
- Most lightweight 90 kVA unit on the market
- Individual output power range:
  - 22.5 kVA (2 **D**ynamic **I**nverter **M**odules) - Model type BPV, BPM 020
  - 45.0 kVA (4 **D**ynamic **I**nverter **M**odules) - Model type BPV, BPM 045
  - 67.5 kVA (6 **D**ynamic **I**nverter **M**odules) - Model type BPV, BPM 060
  - 90.0 kVA (8 **D**ynamic **I**nverter **M**odules) - Model type BPV, BPM 090

3.3 Mains input

The mains input connection to be externally pre-fused according to the table below:

100% load @ load power factor 0.8 lagging:

Rating [kVA]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 380 V**	29	59	88	118	147	176	206	235
Recommended Fuse Size [A]	32	63	100	125	160	200	250	250

100% load @ load power factor 0.8 lagging:

Rating [kVA]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 400 V**	28	56	84	112	140	168	196	223
Recommended Fuse Size [A]	32	63	100	125	160	200	200	250

100% load @ load power factor 0.8 lagging:

Rating [kVA]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 480 V**	23	47	70	93	116	140	163	186
Recommended Fuse Size [A]	32	63	100	100	125	160	200	200

100% load @ load power factor 1.0 (unity):

Rating [kVA/kW]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 380 V**	37	74	110	147	184	221	257	294
Recommended Fuse Size [A]	63	100	125	160	200	250	300	300

100% load @ load power factor 1.0 (unity):

Rating [kVA/kW]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 400 V**	40	70	105	140	175	210	244	279
Recommended Fuse Size [A]	63	100	125	160	200	250	250	300

100% load @ load power factor 1.0 (unity):

Rating [kVA/kW]	**22.5**	**45.0**	**67.5**	**90.0**	**112.5**	**135.0**	**157.5**	**180.0**
Line Current [A] **@ 480 V**	29	58	87	116	146	175	204	233
Recommended Fuse Size [A]	32	63	100	125	160	200	250	250

4 Detailed technical description

4.1 Functional description

The basic principle of a B-Power solid-state frequency converter unit is shown below:

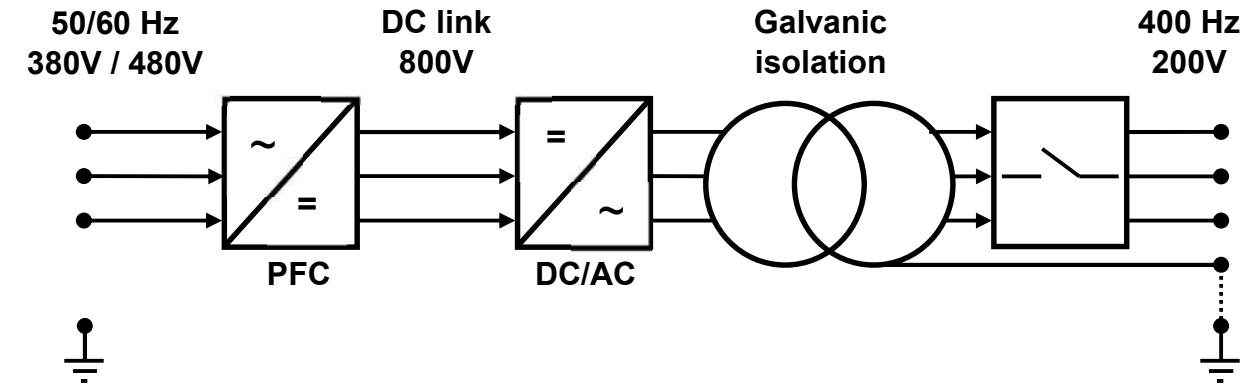


Figure 2 Functional description

The AC input mains voltage is rectified into DC via active power factor control. As a result, the converter input currents are sinusoidal with very low distortion and no reactive power load on the mains (power factor 1). Additionally, the DC link voltage is controlled at a constant level even under input frequency and voltage fluctuations.

Next, the DC/AC inverter converts the stabilized DC link voltage into 400Hz AC voltage. With low pass and e.m.c. filtering inside the inverter the transformer is feed with pure sinusoidal voltage.

The transformer adjusts voltage to an appropriate level and does galvanic isolation.

4.2 Inverter module concept

In comparison to other GPU concepts, B-Power relies on power electronics by using inverter modules. The outline of a typical configuration for a **90 kVA @ unity (power factor 1 -> 90 kW)** unit is shown below:

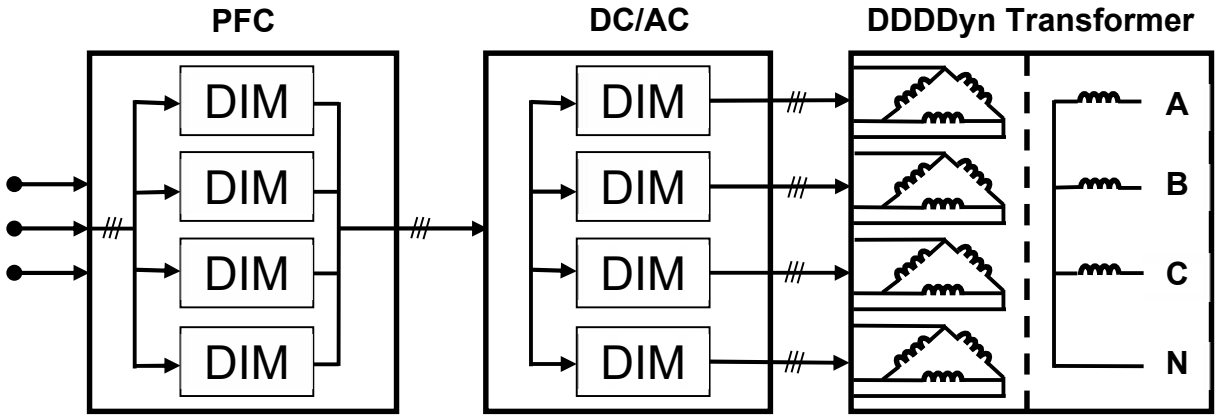


Figure 3 Inverter module concept for 90kVA

Shown in figure 3, the 90 kVA PFC rectifier is designed using **four** dynamic inverter modules (DIM) in parallel which feed their DC output voltage to a common DC bus. Moreover, the 400 Hz AC conversion is also implemented using **four** DIMs in parallel. Thereby, each DIM feeds its 400Hz AC output voltage into its own primary winding of the output transformer. Inside the transformer the power of the four output modules are magnetically accumulated.

The outline of a typical configuration for a **20 kVA (22.5 kVA) @ unity (power factor 1 -> 22.5 kW)** unit is shown below:

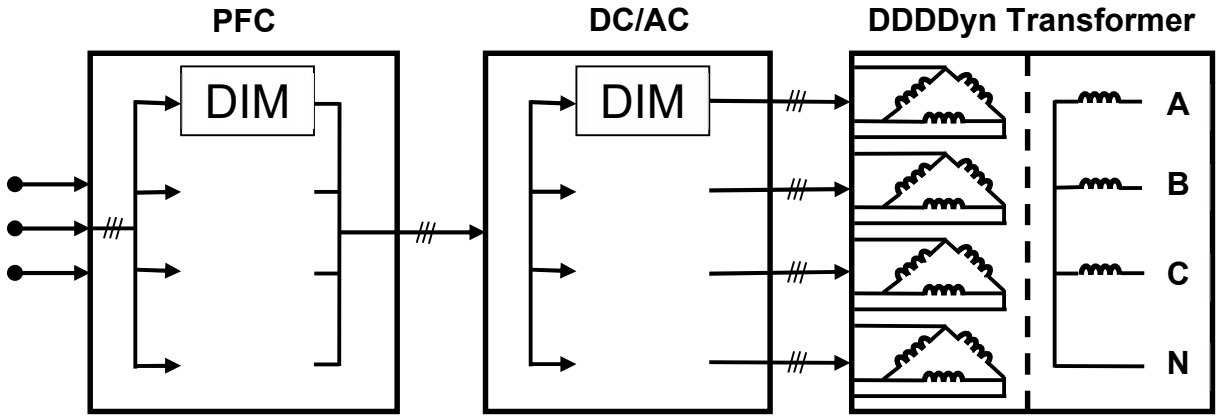


Figure 4 Inverter module concept for 22.5kVA

Shown in figure 4, the 20 kVA (22.5 kVA) PFC rectifier is designed using **one** dynamic inverter module (DIM) which feeds its DC output voltage to a common DC bus. Moreover, the 400Hz AC conversion is also implemented using **one** DIM. Thereby, the DIM feeds its 400Hz AC output voltage into its own primary winding of the output transformer. The 20 kVA (22.5 kVA) @ unity (power factor 1) unit can be easily upgraded to a 90 kVA @ unity (power factor 1) unit by adding six dynamic inverter modules (DIM).

The outline of a typical configuration for a **45 kVA @ unity (power factor 1 -> 45 kW)** unit is shown

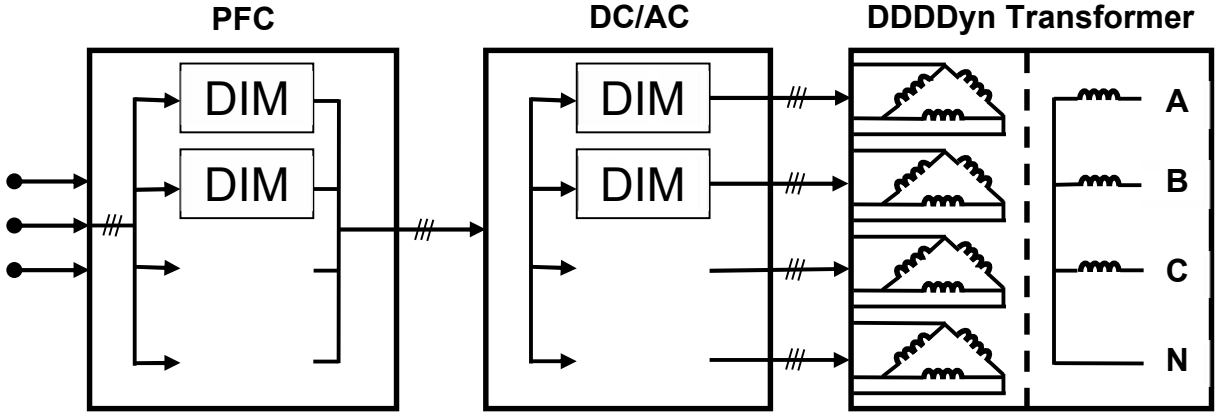


Figure 5 Inverter module concep for 45kVA

Shown in figure 5, the 45 kVA PFC rectifier is designed using **two** dynamic inverter modules (DIM) in parallel which feed their DC output voltage to a common DC bus. Moreover, the 400 Hz AC conversion is also implemented using **two** DIMs in parallel. Thereby, each DIM feeds its 400Hz AC output voltage into its own primary winding of the output transformer. Inside the transformer the power of the two output modules are magnetically accumulated. The 45 kVA

@ unity (power factor 1) unit can be easily upgraded to a 90 kVA @ unity (power factor 1) unit by adding four dynamic inverter modules (DIM).

The outline of a typical configuration for a **60 kVA (67.5 kVA) @ unity (power factor 1 -> 67.5 kW)** unit is shown below:

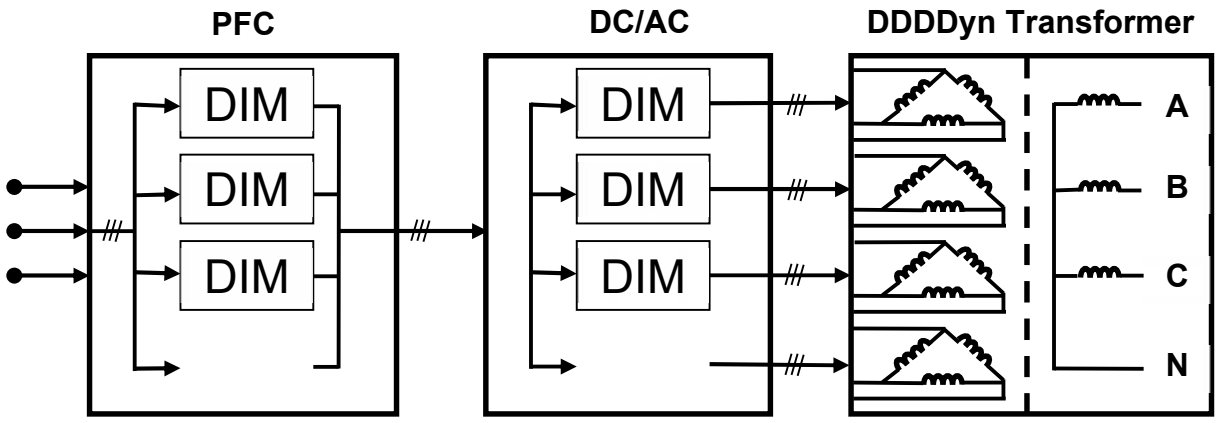


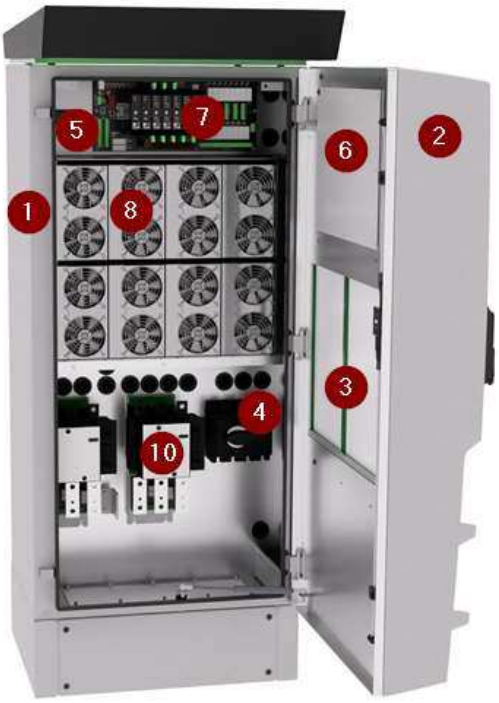
Figure 6 Inverter module concept for 60kVA

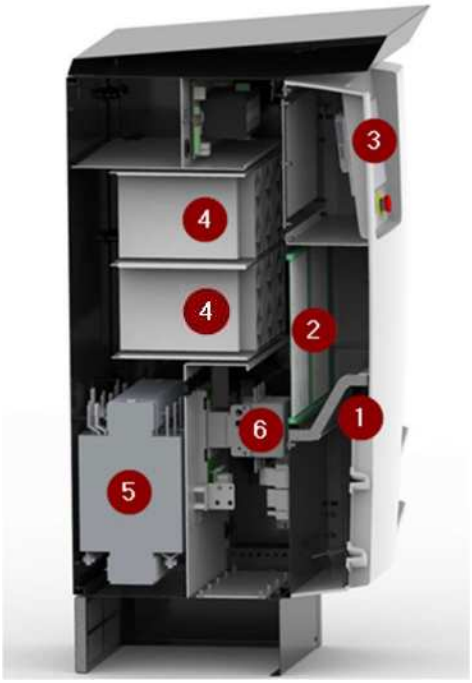
Shown in figure 6, the 60 kVA (67.5 kVA) PFC rectifier is designed using **three** dynamic inverter modules (DIM) in parallel which feed their DC output voltage to a common DC bus. Moreover, the 400Hz AC conversion is also implemented using **three** DIMs in parallel. Thereby, each DIM feeds its 400Hz AC output voltage into its own primary winding of the output transformer. Inside the transformer the power of the **three** output modules are magnetically accumulated. The 60 kVA (67.5 kVA) @ unity (power factor 1) unit can be easily upgraded to a 90 kVA @ unity (power factor 1) unit by adding two dynamic inverter modules (DIM).

4.3 Main components

Our BPV exists of following main components:

- Enclosure **(1)**
- Lockable front door **(2)**
- Cooling system with filters **(3)**
- Input disconnect switch **(4)**
- Auxiliary power supply unit (24V) **(5)**
- Display panel **(6)**
- DSCP Control PCB **(7)**
- Dynamic Inverter Module (DIM) **(8)**
- Output transformer
- Output contactor **(10)**





(1) PPI 10 air inlet filter mat

(2) Viledon® P15/500S EU4/G4 air inlet filter mat

(3) Display panel

(4) Dynamic Inverter Modules (DIM)

(5) Output transformer

(6) Output contactor

4.4 Mechanical

4.4.1 BPV version (Floor-mounted)

The main mechanical components of the BPV is a powder coated aluminum enclosure and related lockable PC UV front door.

4.4.1.1 Enclosure

The solid-state ground power unit is housed in a powder coated aluminum enclosure, painted in RAL DESIGN 000 2000 slate black.

For easy access to the 400 Hz output transformer, the back of the aluminum enclosure is equipped with a lockable back door that can be opened and locked with a double bit key.

Due to a smart ventilation and cable entry concept from the bottom connection plate, a 180 mm high plinth was considered to level the unit. The side parts of the plinth are made of stainless steel, the front and rear part of powder coated aluminium. Optionally, the base can be levelled by an additional 180 mm high plinth.

The enclosure is environmentally protected by a powder coated aluminium cover on the roof.

All parts are painted in RAL DESIGN 000 2000 slate black.

4.4.1.2 Lockable front door

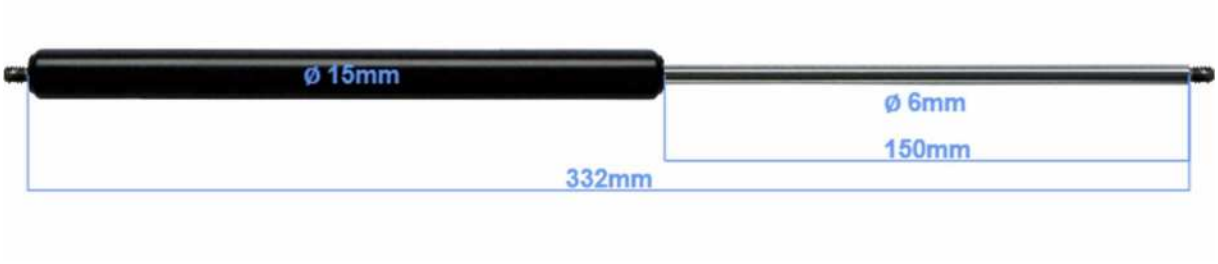
The lockable front door houses the touch display, the control parts with emergency stop push button, main switch, control buttons and special designed air inlet with air filters. The unit is made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 7500 marble grey.

The lockable front door is equipped with a lockable swing handle with cylinder according to DIN 18252/28254.

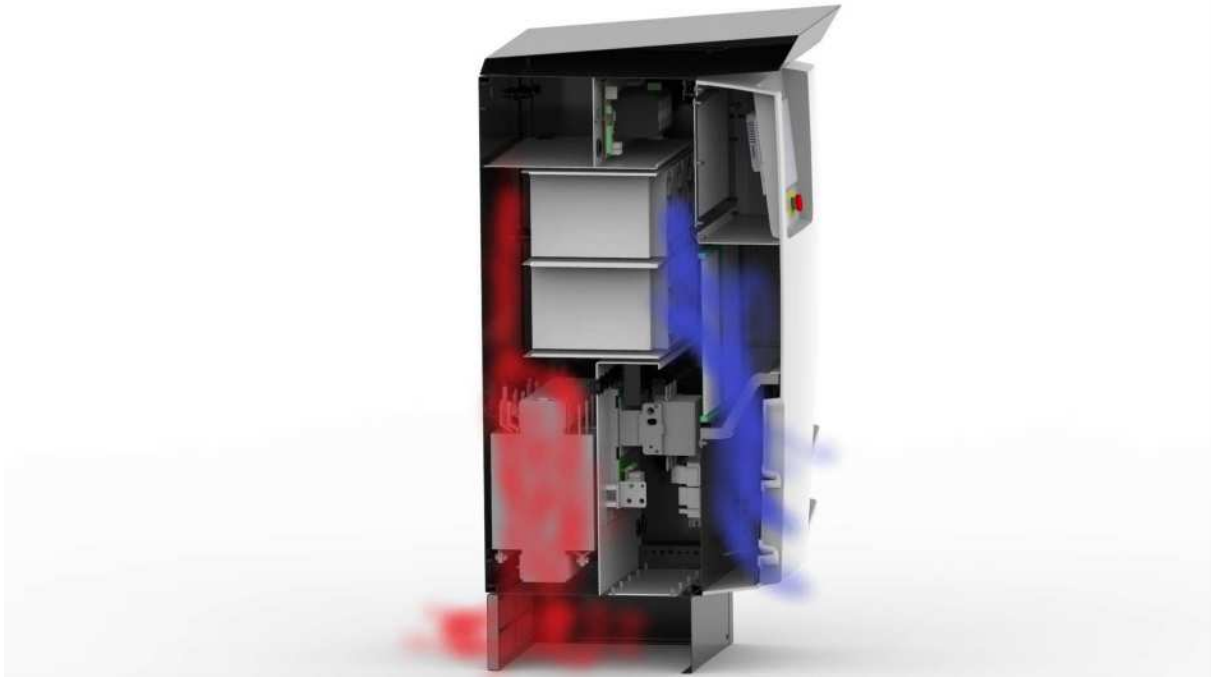
Dimensions (L x W x H):	600 x 236 x 1208 mm
Painting:	RAL DESIGN 000 7500 marble grey

In order to open and close the front door of the BPV, the lockable door is equipped with a gas spring damper.

Piston rod:	6 mm
Tube:	15 mm
Stroke:	150 mm
Length:	332 mm



4.4.1.3 Cooling system



An efficient ventilation and cooling concept was integrated into the BPV. Fresh air is supplied via integrated ventilation inlets in the front door, which is equipped with a PPI 10 and a Viledon® P15 / 500S EU4 / G4 filter mat. The filter mats are easily accessible and can be replaced within a very short time (<1 min).

Inside the BPV, the air is also routed through the Dynamic Inverter Modules (DIM), which are equipped with two temperature-controlled fans per DIM to cool the active section.

The air flow controlled by the DIM fans ultimately flows through the 400 Hz output transformer and exhaust air outlet on the back of the base plinth which is further protected with a PPI 10 filter mat.

4.4.2 BPM-M version (Hand movable)

The main mechanical components of the BPM-M are a powder coated aluminum enclosure and related lockable PC UV front door.

4.4.2.1 Enclosure

The solid-state ground power unit is housed in a powder coated aluminium enclosure, painted in RAL DESIGN 000 2000 slate black.

4.4.2.2 Front door

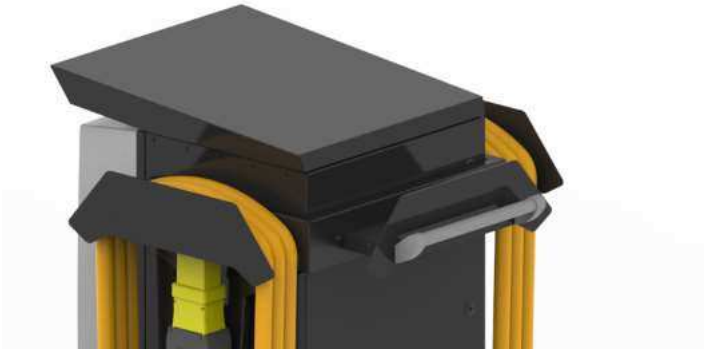
The lockable front door houses the touch display, the control parts with emergency stop push button, main switch, and special designed air inlet with air filters. The unit is made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 7500 marble grey.

The lockable front door is equipped with a lockable swing handle with cylinder according to DIN 18252/28254.

4.4.2.3 Roof cover, cable holders and moving bar

The roof cover and cable holders are made of powder coated aluminium, painted in RAL DESIGN 000 2000 slate black. Maximum length of 400 Hz, 28 VDC and 50/60Hz cable shall be clarified in detail with BGSE.

A handlebar for moving the unit is mounted on the cable holder in the back.



4.4.2.4 Trailer

The solid-state frequency converter is assembled on a powder coated steel trailer with four full rubber tires for low friction and a fender protection at the sides. The wheels are made out Polyurethan (PU) which are more abrasion resistant and suitable for hangar application.

The trailer is coloured in RAL DESIGN 000 2000 slate black.

Characteristics

Material	Powder coated steel
Tires	4 pcs. PU-tires
Included	Robust fender system
	Handlebar for moving application
	Parking brake
RAL colour chassis	RAL DESIGN 000 2000 slate black

4.4.3 BPH-T version (Mobile towable)

The main mechanical components of the BPH-T are the stainless-steel enclosure, PC UV flaps, aluminum roof cover, cable holders, and steel trailer.

4.4.3.1 Enclosure

The solid-state ground power unit is housed in a powder coated stainless steel enclosure, painted in RAL DESIGN 000 2000 slate black.

4.4.3.2 Side flaps

The side flaps are made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 7500 marble grey.

4.4.3.3 Front flap

The front flap is made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 2000 slate black.

4.4.3.4 Roof cover and cable holders

The roof cover and cable holders are made of powder coated aluminum, painted in RAL DESIGN 000 2000 slate black.

4.4.3.5 Trailer

The B-Power Solid-State Ground Power Unit is assembled on a powder coated steel trailer with three full rubber tires for low friction and a maximum speed of 25 km/h. The trailer is equipped with a robust bumper system, integrated extra big and protected cable storage trays and forklift pockets. The drawbar comes with a parking brake in horizontal and vertical position and a DIN40 drawbar eye. For human safety, the horizontal position is limited to 100 mm from the bottom. The trailer is coloured in RAL DESIGN 000 2000 slate black.

Characteristics

Material	Powder coated steel
Speed	Max. 25 km/h
Tires	3 pcs. full rubber tires
Included	Robust bumper system
	Extra big and protected cable storage trays
	Drawbar
	Parking brake
	Forklift pockets
Standard towing eyelet	68 mm inner Ø
	118 mm outer Ø
	25 mm thickness
RAL colour	RAL DESIGN 000 2000 slate black

4.4.4 BPH 090 + BCH 090 (bridge mounted version)

The BPH + BCH is a combination of solid-state frequency converter and cable coil for bridge mounted application. It can be easily mounted via customized mounting frame supplied by BGSE.

4.4.4.1 Enclosure

The solid-state ground power unit is housed in a powder coated stainless steel enclosure, painted in RAL DESIGN 000 2000 slate black.

4.4.4.2 Side flaps

The side flaps are made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 7500 marble grey.

4.4.4.3 Front flap

The front flap is made of recyclable, ultraviolet-resistant polycarbonate (PC UV) in RAL DESIGN 000 2000 slate black.

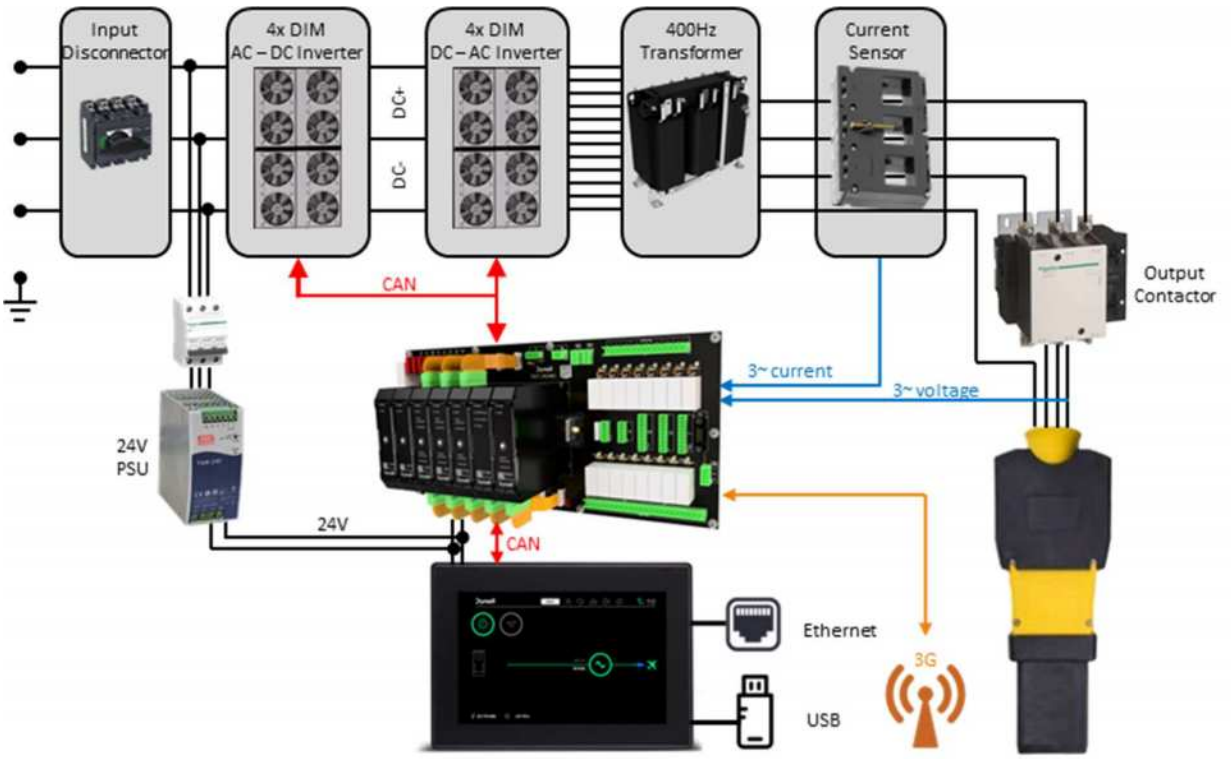
Characteristics

Material	Stainless steel
Including	Static frequency converter Cable coil Mounting frame
RAL Colour	RAL DESIGN 000 7500 marble grey RAL DESIGN 000 2000 slate black

4.5 Electrical

4.5.1 Schematic wiring diagram

The figure shown below shows the simplified wiring diagram for a BPV 090 (90kVA frequency converter):



4.5.2 Input disconnect switch

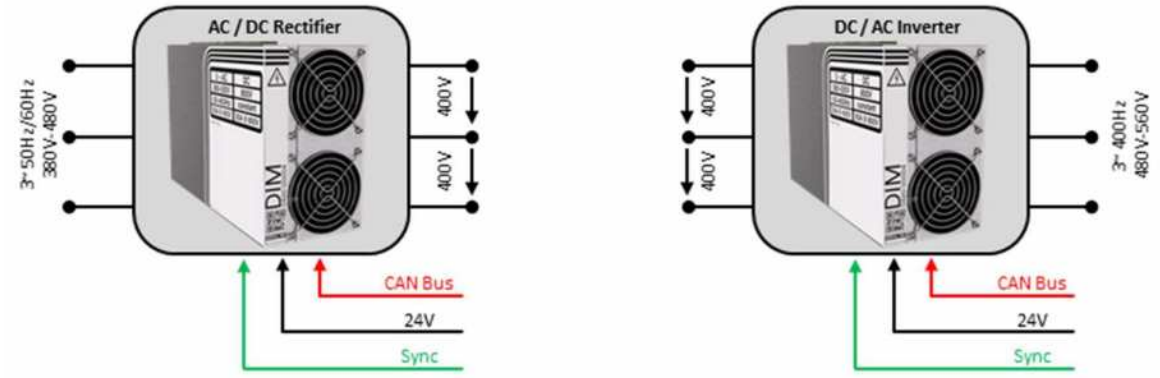
It fully disconnects the input mains from the ground power unit. Once closing this switch, the ground power unit powers up its PLC and stays in standby operation.

4.5.3 Auxiliary power supply unit (24V)

The 24V DC power supply unit is the common power supply for PLC components, display unit and cooling fans. It has an input voltage range from 340V to 550V.

4.5.4 Dynamic Inverter Module (DIM)

The **D**ynamic **I**nverter **M**odule (DIM) is a bidirectional 3-phase inverter module built with the latest semiconductor technology. As it is an inverter with power flow in both directions, the DIM is used for rectifying the mains voltage and inverting into the 400 Hz voltage (back to back operation). Therefore, the hardware of rectifier (**p**ower **f**actor **c**orrection – PFC) and inverter (DC / AC) is the same. The firmware is automatically switching via the CAN address, that the module receives from the plug-in system on the rear of the module. No address configuration is required – only Plug & Play principle. All other electrical connections are realized via the back plane. In below figure, the DIM is illustrated to be used as rectifier and inverter.



The inverter is built in 3-level structure with latest low-loss semiconductors. This allows a very high switching frequency, whereby very compact passive components (chokes, capacitors) can be selected. Due to the high-power density a module only has ~5 kg. Therefore, the entire active part at 90 kVA output power with 8 modules weighs ~40 kg.

The modules can be easily exchanged via a Plug & Play plug-in system and locked by a lever. As many modules of the same function are operated in parallel, there are numerous advantages:

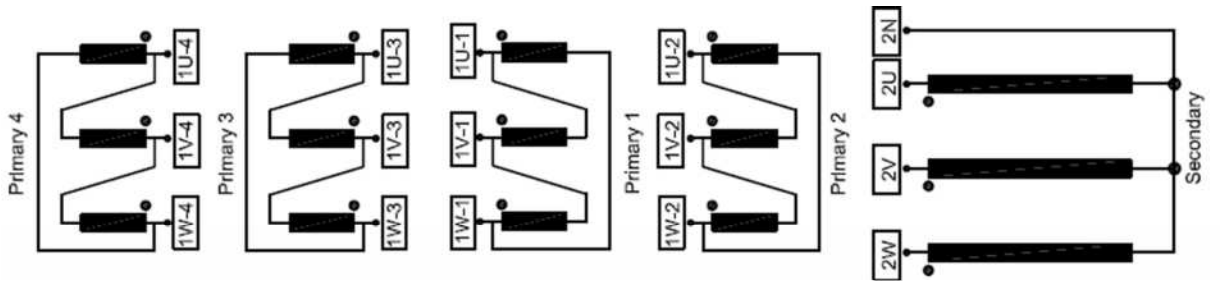
- Number of in- and output modules does not necessarily have to be same, e.g. if a output power factor of 0.8 instead of 1.0 for 90 kVA (72 kW) is requested, 4 modules for the output but only 3 modules on the input side are required, in total 7 instead of 8 modules.

- Redundancy: If a module fails due to a fault, the performance is only reduced by 22.5 kVA and the unit still supplies power, e.g. 67.5 kVA instead of 90 kVA.
- In the partial-load operational range, modules may even be switched off in order to further increase the overall efficiency of the unit.
- Customers/Clients can stock a spare power module to make the unit ready for 100% use immediately in the event of a fault by exchanging the faulty power module at relatively low cost as one module is only 1/8 of the active part.

The unit is designed according to the specifications in the DFS 400 standard for modified protective separation in agreement with the main international airports with very low leakage capacitance at the output, very low leakage currents and low neutral against earth voltage.

4.5.5 Output transformer

The 400Hz output transformer steps down the voltages from the DIM inverter modules into the required aircraft voltage. Each transformer has four sets of primary windings (DDDDyn), where each set is feed from one DIM module. One transformer can handle in total up to 90kVA output power. For power ratings higher 90kVA a second transformer is required.



The output transformer also ensures a galvanic isolation between primary to secondary and primary or secondary to earth. This insulation system is designed for DFS400 protective isolation, which includes rated insolation voltage of 4kV AC.

4.5.6 Output contactor

The output contactor connects the voltage from output transformer to 400Hz aircraft cabling. In case of internal or external errors, or when the unit stops regularly, the contactor immediately disconnects the outlet. This guarantees that the connected output cabling is deenergized and safe.

4.5.7 Cabling

Cable entry

All cables are fed into the cabinet via a connection plate at the bottom of the unit. Thereby, it is important to ensure that sealed cable glands are used to prevent parasitic and unfiltered air flow.

Cable sizing

The input cables should be sized in accordance with the upstream protective device, also considering a voltage drop for longer supply lines under all load conditions. The BPV is designed to operate for a three-phase supply without a neutral conductor (3 phase mains + PE). However, the unit is also prepared for connecting a 5-wire cable (3 phase mains + neutral + PE).

The output cables must be selected to match the power capacity of the BPV. Considering a 90kVA unit, typically 70mm^2 cables are used. BGSE recommends single core wires (e.g. 4x70mm^2) for short distances due to the voltage drop which is relatively high and even symmetrical loads lead to an asymmetrical voltage at the aircraft plug. For longer output cables, the use of symmetrical cables (e.g. 7x35mm^2) with a significant smaller voltage drop and distortion is recommended.
BGSE will be happy to assist in the selection of the suitable cable.

4.6 Programmable Logic Controller System (PLC)

4.6.1 Overview

Our PLC (Programmable Logic Controller Systems) provides an economical solution to fit demands for ground power unit control and can be offered with modular architectures with a range of I/O, measurement, and network options.

A weatherproof 7” intuitive touch display is the heart of the control system. The display works on the projected capacitive technology leading to maximum robustness besides perfect handling even with gloves. The panel CPU operates on real time Linux with enough power for

controlling ground power units. BGSE uses C++ as its programming language and HTML5 for visualization, which are established as worldwide standards. This guarantees that BGSE stays manufacturer independent in contrast to proprietary programming and visualization environments which are restricted to few manufacturers. Although we buy panels from external quality manufacturer , we can guarantee long availability of identical or compatible components independent of external product strategies of suppliers . This is a big advantage for our customers concerning future availability of spare parts.

The panel has a CAN-BUS interface for data exchange (based on standardized CAN OPEN protocol) with peripheral modules. BGSE currently offers following in-house developed modules:

- Input-Output: 8x digital input + 8x digital output
- Voltage / Current / Power: 3-phase power measurement
- PWM: 8x pulse width modulated digital output
- Control system and power management (8x DI + 8x DO)
- Communication 2G/3G and GPS modem

These modules can be easily snapped onto a space saving standard DIN rail with the back plane connector. Thus, they are automatically connected to power supply and communication without additionally wiring.

Regarding our DCB (Bridge mounted Cable Coil) unit, we are optionally able to carry out data exchange using a CAN OPEN protocol with the frequency-controlled drive.

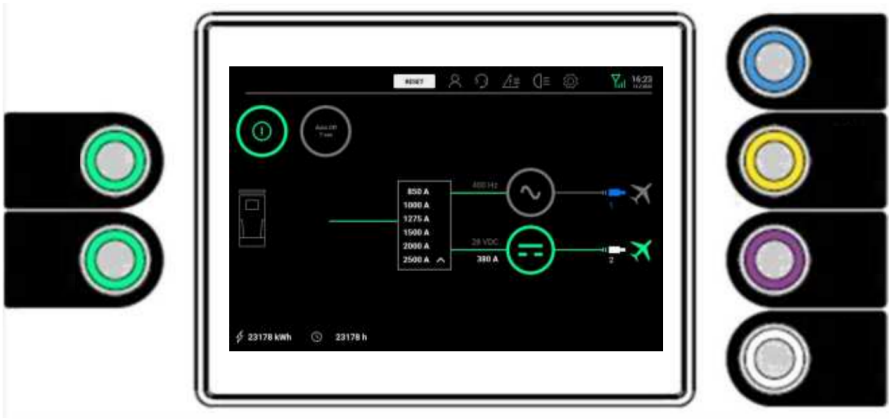
The display panel has several ethernet sockets. BGSE offers MODBUS TCP as its standard ethernet based communication protocol. However, we are open to do external data exchange based on other protocols (Modus RTU, Profibus, BACnet, …) based on gateway modules.

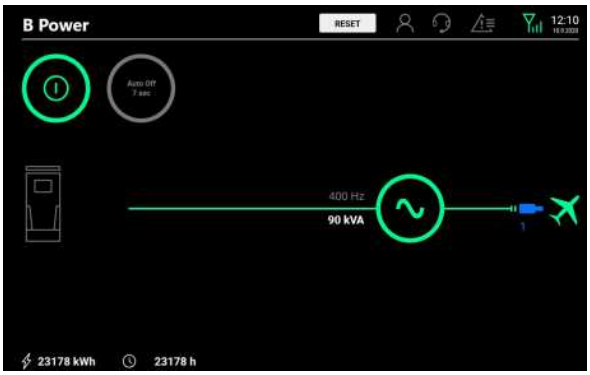
In the following chapter, the individual modules of the PLC system are described more in detail:

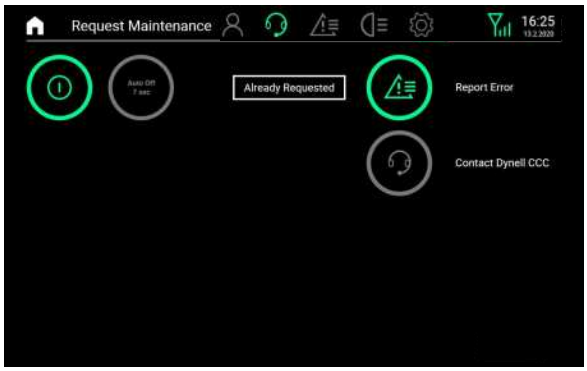
4.6.2 Visualization concept

The graphic user interface sets new standards among other ground power unit HMI devices. With its touch screen technology, it offers operator and maintenance staff both, a bright clear display with important information and the flexibility of touch screen input.

For easy and fast operation on the apron, the HMI comes with up to six buttons (four buttons standard) for additional control of the main functions.







The taskbar hold following functions:

 Login: Maintenance staff, (optional) Operator

 Request Maintenance

 Data Recorder (Error Log)

 Options

 Settings

4.6.3 Display panel

The 7” TFT colour display with projected capacitive touchscreen serves for human machine interaction. The display unit has also an integrated PLC CPU with Ethernet (Modbus TCP), CAN (CAN open, J1939), SD card slot and USB interfaces.

Key Features

- HW and FW Optimised for Extremely Fast Operation
- System and Project Rapid Boot-Up
- Operating System: Linux RT
- Brilliant 2,100,000 pixel Display
- Wide Angle Visibility
- Beautiful 16,000,000 Colours
- Resistant to Scratches, UV and Chemicals
- Total Glass Design
- Network Separation possible via up to 3 Ethernet
- Plug In Modules for System Expansion

Technical Data

Display – Colours	7” TFT 16:9 LED – 16M
Resolution	800x480, W8GA
Dimming	to 0%
Brightness	500 Cd/m² typ.
Touchscreen	True Glass Projected Capacitive, Multitouch
CPU	ARM Cortex-A9 dual core 800 MHz
Flash / RAM	4 GB / 1GB
Additionals	Real Time Clock, RTC Back-Up, Buzzer
Ethernet port	3 (port 0 – 10/100/1000, port 1/2 – 10/100)
USB port	2 (Host V2.0, max. 500 mA)
SD card	Yes

Power supply	24 VDC (10 to 32 VDC)
Current consumption	0.7 A at 24 VDC (max.)
Battery	Rechargeable Lithium battery, not user-replaceable
Operating temperature	-40 to +60°C
Storage temperature	-40 to +70°C
Humidity	5-85% RH, up to 95% RH (front), non condensing
Protection class	IP66 (front), IP20 (rear)
Faceplate LxH	187x147 mm (7.36x5.79”)
Cutout AxB	176x136 mm (6.93x5.35”)
Depth	47+8 mm (1.85+0.31”)
Weight	1.5 kg

4.6.4 PLC-DIO Input Output Module

The digital input / output module has eight isolated general-purpose inputs with 9V to 36V input voltage range. The individual high / low information is sent via CAN open to panel CPU and status is indicated with individual LED on module front. In addition, panel CPU sends high/low status to this module for controlling peripheral devices like relays.

Supply voltage:	9-36V
Digital Inputs:	8x isolated inputs with LED status indication
Digital Outputs: indication (500mA)	8x open collector outputs with LED status
Degree of protection:	IP20
Ambient temperature:	-40°C to +60°C
Storage temperature:	-40°C to +70°C
Width	22.5mm
Depth	110mm
Height	100mm
Weight	~100g

4.6.5 PLC-Ctrl System and Power Management Module

The system and power management module is built up very similar to the DIO digital input/output module. The main difference is that this module itself does standalone logic sequences, which are e.g. used to handle start button to power up the unit.

Supply voltage:	9-36V
Digital Inputs:	8x isolated inputs with LED status indication
Digital Outputs:	8x open collector outputs with LED status indication (500mA)
Degree of protection:	IP20
Ambient temperature:	-40°C to +60°C
Storage temperature:	-40°C to +70°C
Width	22.5mm
Depth	110mm
Height	100mm
Weight	~100g

4.6.6 PLC-PWM Pulse Width Modulation Module

The PWM module holds eight digital outputs which are pulse width modulated. The duty cycle of each output can be set from panel CPU via CAN open, what can be used e.g. for colour and intensity configuration of status LEDs of ground power units.

Supply voltage:	9-36V
Digital Outputs:	8x open collector pulse width modulated outputs with LED status indication (500mA)
Degree of protection:	IP20
Ambient temperature:	-40°C to +60°C
Storage temperature:	-40°C to +70°C
Width	22.5mm
Depth	110mm
Height	100mm
Weight	~100g

4.6.7 PLC-VCP Voltage / Current / Power Measuring Module

The VCP module is a three-phase power measuring module especially designed for 400Hz applications. It has current inputs measuring via current-transformers and direct voltage inputs, where 4kVAC isolating distance against PE can be realized without additional isolating transformers. This is important feature what is used to fulfil protected isolation with respect to DFS400 standard.

Supply voltage:	9-36V
Current Inputs:	3~ 50Hz/400Hz current measurement
Voltage Inputs:	3~ 50Hz/400Hz current measurement

Measurement:	single phase and average current single phase and average voltage single phase and total power single phase and total apparent power single phase and average power factor phase rotation
Degree of protection:	IP20
Ambient temperature:	-40°C to +60°C
Storage temperature:	-40°C to +70°C
Width	22.5mm
Depth	110mm
Height	100mm
Weight	~100g

4.6.8 PLC-COM 2G/3G and GPS Modem

The communication modem is a perfect solution for remote wireless data communications worldwide. With standard sim card it can be used for communication with a BGSE server. In addition, it has GPS receiver for position detection / tracking.

Supply voltage:	9-36V
Antenna input 1:	3G antenna
Antenna input 2:	GPS antenna
Sim card slot:	standard size sim card
Degree of protection:	IP20
Ambient temperature:	-40°C to +60°C
Storage temperature:	-40°C to +70°C
Width	22.5mm
Depth	110mm
Height	100mm
Weight	~100g

4.6.9 Static Control PCB (SCP)

With the control PCB board B-Power introduces state of the art switch gear wiring into ground power units using PCB technology. Contrary to conventionally built switch gears, the PCB approach has following advantages:

- Complex wiring is replaced by printed circuit board
- Fail-safe connection between PCB mounted components (no loose cables)
- Space saving
- Clearly arranged and labeled setup
- Only spring-type terminals
- Specially customized for BGSE Ground Power Units
- Easy to replace in case of fault

A DIN rail is fixed onto the PCB to hold the peripheral modules. Using thin and reliable flex wires, the inputs / outputs of the modules are connected onto the board.

4.7 Features & Protections

4.7.1 Protections

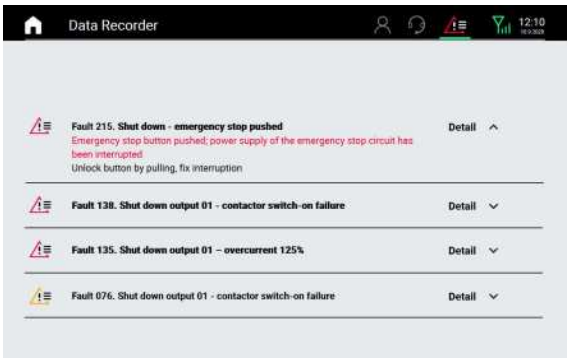
The following standard form of protections are provided (amongst others):

- Input (mains) under and over voltage
- Input (mains) under and over frequency
- Input (mains) overload
- Output (400Hz) under and over voltage
- Output (400Hz) under and over frequency
- Output (400Hz) Phase sequence
- Output (400Hz) overload
- DC Link under and overvoltage
- Short circuit at output
- Over temperature

In case the monitored values exceed limits the unit automatically shuts down the DIM modules, opens the output contactor and indicate tripped failure with appropriate error dialog.

4.7.2 Features

- **Status / Error Log:**
  All current error and status information are clearly shown in full text (not just error codes) on the graphical display.



  In addition, the unit logs previous information including black box data on internal non-volatile memory what can be read out by placing USB flash stick into display slot. However, an even more convenient way is to use BGSE cloud services.

- **Power Log:**
  The power consumptions of previous operations are logged together with start and end time. This information can be read out by using USB flash stick; however, an even more convenient way is to use BGSE cloud services.

- **Self-diagnostics during start up:**
  When a 400Hz output is requested the DIM module first do self-diagnostics on critical components and stops starting procedure if extraordinary situation is detected. This prevent further damage of the unit itself, but also damage of connected aircraft.

- **MODBUS TCP Interface:**
  The GPU is designed with a TCP/IP data communication port. The standard software includes MODBUS communication protocols. Relevant data are documented in MODBUS parameter list.

- **No Break Power Transfer (NBPT) capability:**
  The ground power unit can handle misalignment of three-phase voltages between aircraft internal APU and external ground power supply. Even if bigger amounts of energy are fed back from aircraft into the GPU, it doesn't trip the unit.

- **Temperature controlled ventilation:**
  All fans are temperature controlled dependent to minimize acoustic noise and to maximise lifetime. Additionally, each fan rotation is monitored, and warning is indicated in case of fan failure.

- **90% Switch Interlock:**
  If activated the unit can only switch on output if 90% switch is on. This feature can also be bypassed, especially for plugs without 90% contact.

- **Interlock (EF) Bypass:**
  Due to safety reasons, the output contactor only stays closed if 28VDC is provided on F terminal of the aircraft connector. However, for maintenance and test reasons the EF handling can be bypassed. This is only possible for trained people and the setting is password protected.

- **Line drop compensation**:
  The unit can compensate the voltage drop between the ground power unit and the aircraft connector. This LDC feature can be carried out using voltage sense wires, which therefore directly control the phase voltages at the aircraft connector. Moreover, the unit can also compensate the voltage drop mathematically without extra sense wires, if certain cable parameters are set on the display interface.

4.7.3 Output cables and connector

The solid-state GPU can be delivered in combination with various cable arrangements, such as,

- Cable coil
- Cable carrier
- Standard output cable with connector
- Pit-system
- Distribution Pillar
- Depending on its application

Therefore, please refer to your quotation or BGSE representatives for more details about output cable and connectors.

5 Options

5.1 Standard Options

- **Neutral Voltage Supervision:**
  For ground power supply where neutral is not grounded, the voltage difference neutral to earth is continuously monitored and the unit trips in case of limit exceeding.

- **Earth Leakage Supervision:**
  For ground power supply where neutral is grounded, the residual current in the internal neutral to earth connection is monitored and the unit trips in case of limit exceeding.

- **Broken Neutral Supervision:**
  The broken neutral supervision injects a low amplitude test current between the neutral and an additional control wire. If the current flow is interrupted, a broken neutral is identified and the unit trips. The advantage of this approach is that broken neutral can be detected right before the aircraft is supplied.

- **Modified Protection System according DFS 400 standard (4 kV testing voltage):**
  All active parts from 400Hz output including cabling, aircraft connector and other connected devices show double or enhanced Isolation. This will be proven with 4kV AC testing against PE.

- **Additional Output Contactors:**
  One output contactor is standard for BGSE ground power units up to 90kVA, but one additional output contactor can optionally be equipped. Typically, those two outputs are interlocked to each other and only one contactor can be active at time. If multiple outputs shall supply from same source simultaneously, the voltage regulation can only be realized by keeping the average value of all active outputs' constant.

  Two output contactors are standard for ground power units >90kVA. However, also additional output contactor can optionally be equipped. If optional output contactors are required please ask our representative for assistance.

- **Additional Dry Contacts:**
  The highly flexible Programmable Logic Controller System (PLC) can satisfy all of our customers demands. The standard setup covers all typically required input and output contacts. However, we are open to add additional contacts for BMS systems, door interlock, extra indication or link to passenger boarding bridges.

- **Terminal Extension:**
  Two cables per phase can connected to each output contactor (e.g. 7x35mm^2). To overcome longer distances between ground power unit and aircraft connector typically parallel wiring is applied (e.g. 2 || 7x35mm^2). BGSE offers optionally terminal extensions for convenient connections of multiple wires.

- **Anti-Condensation Heater:**
  To avoid dew, a heating element can optionally be installed. This is especially recommended in areas with relatively high humidity.

- **Military Interlock:**
  Th ground power unit is designed for civilian aircraft interlock. Optionally, it can be prepared for military interlock system, where 28Vdc is delivered from the GPU on E pin (no E to F jumper inside the aircraft connector!).

- **Status / Error Light:**
  The ground power unit can be equipped with a multi-colour LED light to indicate operations status or error.

- **Surge arrestor:**
  The ground power unit can optionally be equipped with a surge arrestor on the input (50Hz/60Hz mains) and / or output (400Hz) side for overvoltage protection.

- **(Maintenance) socket-outlet:**
  The ground power unit can optionally be equipped with a socket-outlet.

- **Data Bus Communication:**
  The ground power unit can provide optionally several communication interfaces (MODBUS RTU, BACnet, PROFINET, …).

- **Base module:**
  An additional base module can be applied, which extends the unit height by 180mm.

- **Automatic shutdown - switchable**
  At standard configuration, the GPU automatically shuts down after 20 minutes in case of no required load on the outputs. With this additional option the user has the possibility to activate or deactivate this function via the touch-display.

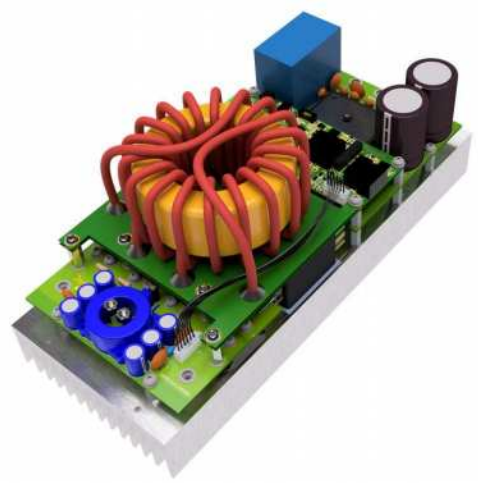
- **Non-Standard Options based on modular PLC system:**
  Due to the flexible PLC system we can realize also extra options based on customer requests. Please ask a BGSE representatives for further details.

- **Other Non-Standard Options:**
  Due to the flexibility of BGSE we can realize also other extra options based on customer requests. Please ask a BGSE representatives for further details.

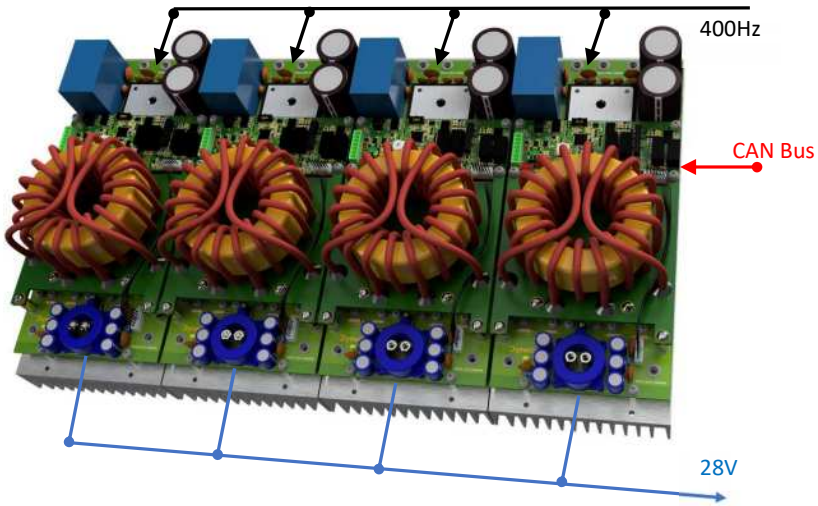
5.2 28VDC Option

The ground power unit can be equipped with a 28VDC outlet. This 28Vdc is generated by rectifying the 400Hz voltage followed by an actively controlled full bridge DC-DC converter (transformer isolated). This keeps the DC output-voltage constant regardless on the varying 400Hz supply voltage.

Comparable to the DIM inverter module also the 28VDC part is build up modular with up to four DC-power modules operating in parallel, as shown below.



Each module has nominal current capacity of 200A and an overload capacity of up to 625A. The most common case is a fully equipped 28VDC option based on four modules as shown below:



Cooling of the unit is realized with one common temperature-controlled fan. Due to the load sharing concept it can be guaranteed that output currents are balanced between the modules and consequentially warming is equal.

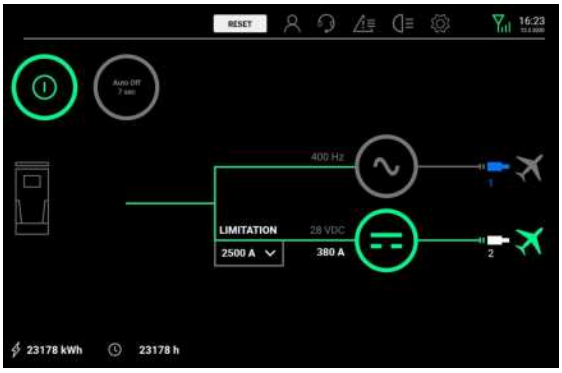
The modular concept leads to additional redundancy. Even if a module fails and stops feeding 28VDC, the remaining modules still supplies DC power.

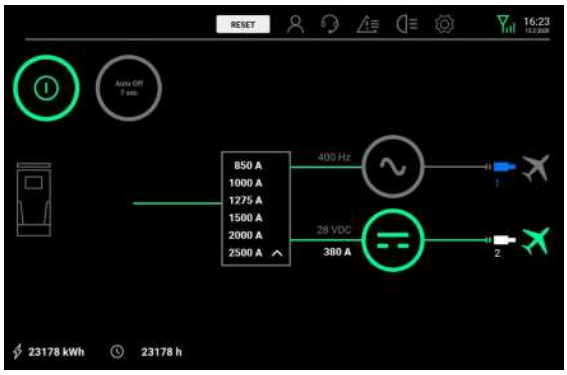
For safety reasons an interlock system is also integrated. It ensures that the output keeps powered only, if the DC output plug is inserted into an aircraft receptacle.

All modules have individual short circuit protection and monitor amongst others temperature, overload, over- and under-voltage.

The modules are also connected to the PLC CAN bus. Thus, features already mentioned for 400Hz are also valid for the 28VDC option like status and error log or BGSE cloud service.

Depending on aircraft type, it can be necessary to adjust the maximum DC current level (850A, 1000A, 1275A, 1500, 2000A, 2500A). This setting can easily be adjusted on the touch panel with our intuitive visualization concept.





Please bear in mind that 28Vdc cables have quite increased current load in comparison to 400Hz cables. Moreover, due to high voltage drop, long output-cables should be avoided. BGSE basically recommends the use of 4x70mm^2 or 2x120mm^2 for fully equipped DC units.

The specification for a four modules unit can be summarized to:

Nominal output voltage	28VDC
Reference output voltage	24VDC – 33VDC
Voltage compensation	0 – 5V (depending on utilization and cable spec)
Nominal output current*	600A continuous*
Static regulation (no load to full load)	1%
Overload capacity:	2500A for 1 sec 1500A for 5 sec 1250A for 2 min 1000A for 4 min 800A for 10 min
Protection	PCB temperature too high Heatsink temperature too high Short circuit on output power limitation acc to overload capability over-/undervoltage acc. to ISO 6858

* Four modules would be able to drive 800A continuously. However, most common aircraft connectors are only rated up to 600A.

The 28VDC option is available for simultaneous or non-simultaneous operation. At simultaneous operation a filter reactor is connected upstream to 400Hz input to minimized distortion to the 400Hz voltage. However, the total power of the unit is the sum of 400Hz output and 28VDC output and limited to the nominal and overload ratings of the 400Hz power.

BGSE can also create economically attractive DC options by reducing the number of modules and, therefore; reduce the current capacity. Please ask a BGSE representatives for further details.

5.3 Remote Maintenance

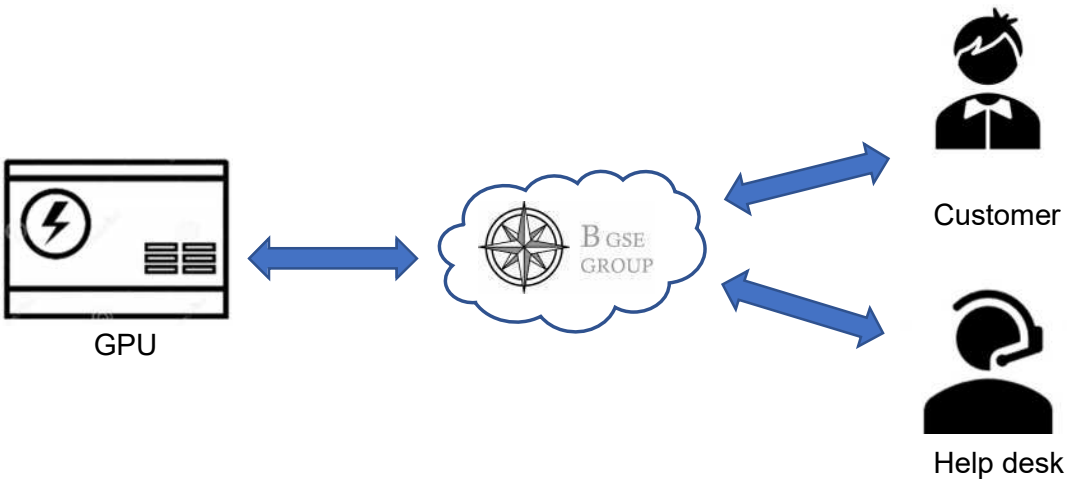
We offer remote maintenance with our telemetry service transmission of fixed set data (e.g. output power, failures, operation hours, etc.) periodically to the cloud. All this data is stored in a database and can be accessed by the customer.

One way to visualize actual and recent data is the BGSE web portal. Other interfaces are possible as well.

This service must be enabled by the customer first to send telemetry data to the cloud.

5.3.1 IoT/cloud security

The BGSE IoT/cloud service uses a centralized server infrastructure. Every communication is managed by the cloud server, so that all clients must connect directly to the server and no bypass is possible. This concept ensures a central instance for cloud communication and security hazards.



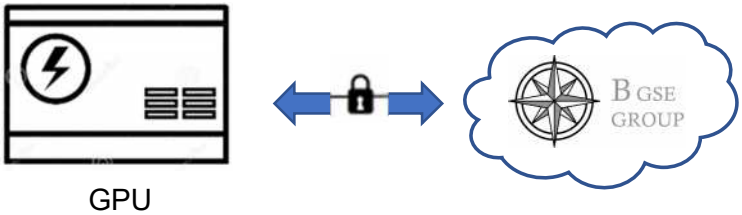
5.3.2 Communication security

All data is routed over a secure communication channel between the device and the cloud server. Since the device is connected to the internet, all accesses from the internet to the device are blocked and the device is only connected to the BGSE unit/service.

Furthermore, there is no direct connection between two or more devices allowed.

The secure communication channel is the only data channel allowed between a BGSE unit and the server. It uses OpenVPN with crypto algorithm EC (Elliptic Curve) prime256v1 and digest sha256.

Every unit has its own different key and certificate to ensure maximum security. In case needed every key and certificate can be revoked on the server and terminate the connection to this device respectively.



GPU

5.3.3 Cloud server security

Every unit is isolated, no direct connection between two or more units are allowed. This is ensured by a firewall on the server.

The data is collected by a central MQTT broker instance, but every data access is restricted to a single unit. Hence, one unit can't access the data of another unit.

There is also a database which saves the data from the MQTT broker. This database service is isolated from the units, so the unit can't access the database or any historic data.

5.4 Telematics

5.4.1 Data collection and analysis of GPU systems

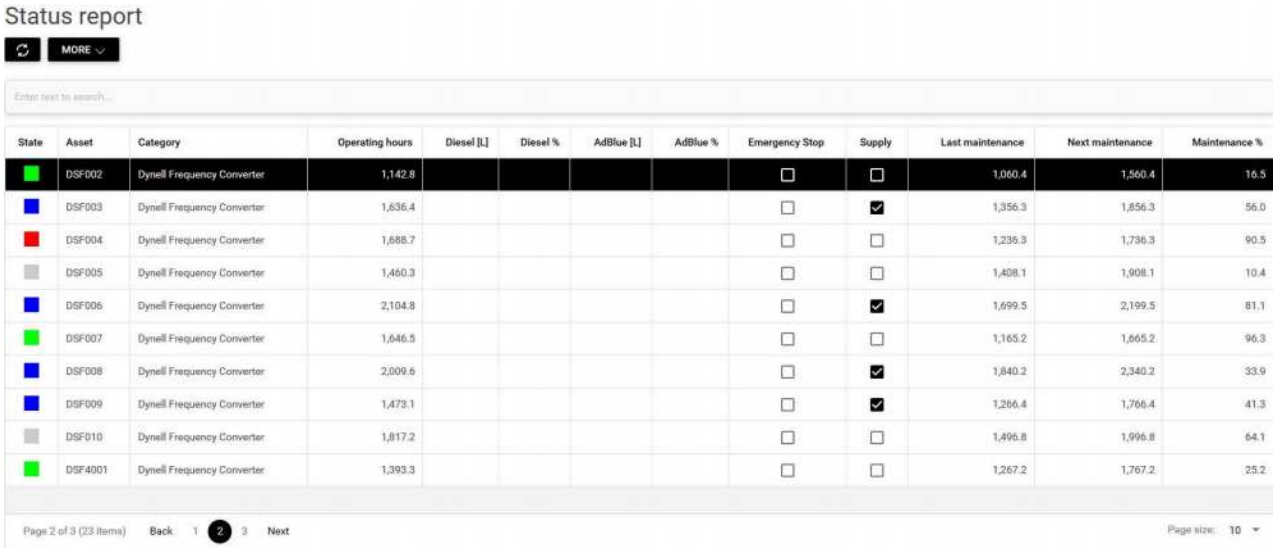
Location and use

Mobile GPU's no longer must be searched for but are made visible on a clear map with location and basic status data. They can be found easily at any time. Alarms like for example when leaving the airport premises can be triggered via geofencing. The utilisation of the GPU's can be evaluated in detail by displaying various states of operation, (e.g. converter running, aircraft is plugged in, aircraft is powered) but also charged accordingly.

5.4.2 User Interface

5.4.3 Status overview

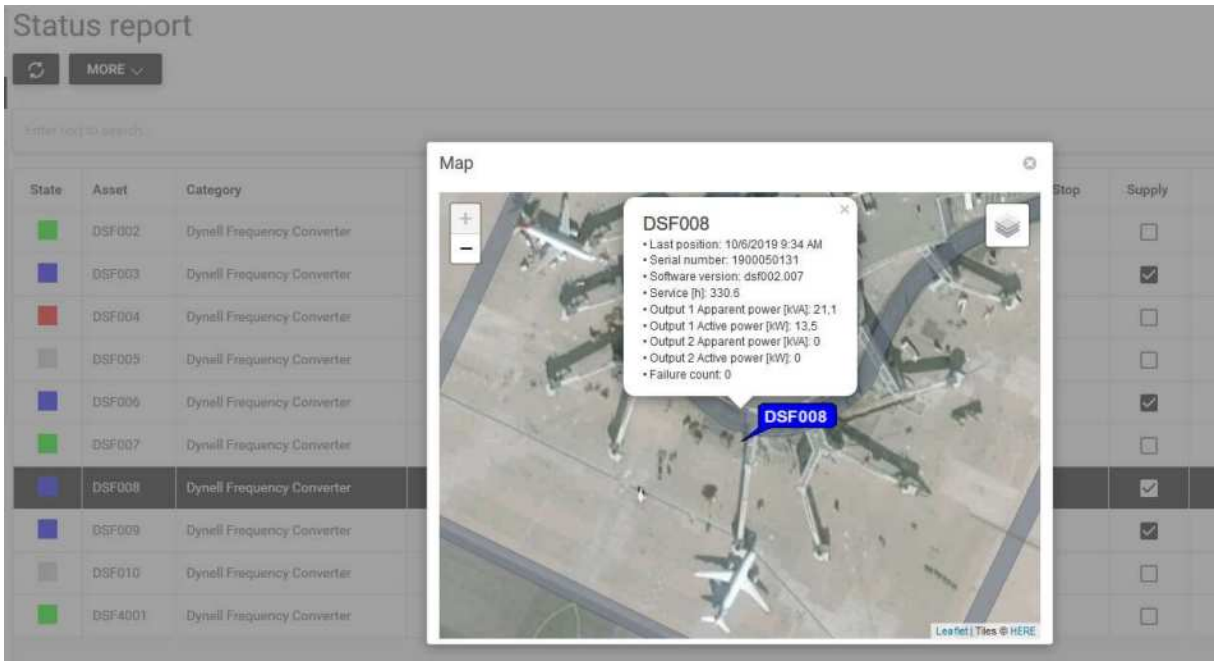
All information requested by the operator are shown individually in the status overview and can be evaluated accordingly. For example, the operating hours (and thus the hours until the next maintenance) that were previously read manually weekly are automated and, above all, up-to-date available. Status informations as well as the information, whether an aircraft is connected or not, are individually adjustable and displayable information.



By clicking into the status report the user can call up the location of the unit, it's last position and the status of each individual unit.

The time of detection of locations can be recorded for various states of operation – operation hours counter, movement, power supply to aircraft to mention a few as examples.

Example of display of various states of operation



Example of display of various states of operation

The data and information are filterable for the respective user and can be called up individually assigned. E.g. for the maintenance partner the operating hours until the next maintenance can be relevant, and this can be scheduled accordingly. The system automatically carries out the reset until the next maintenance.

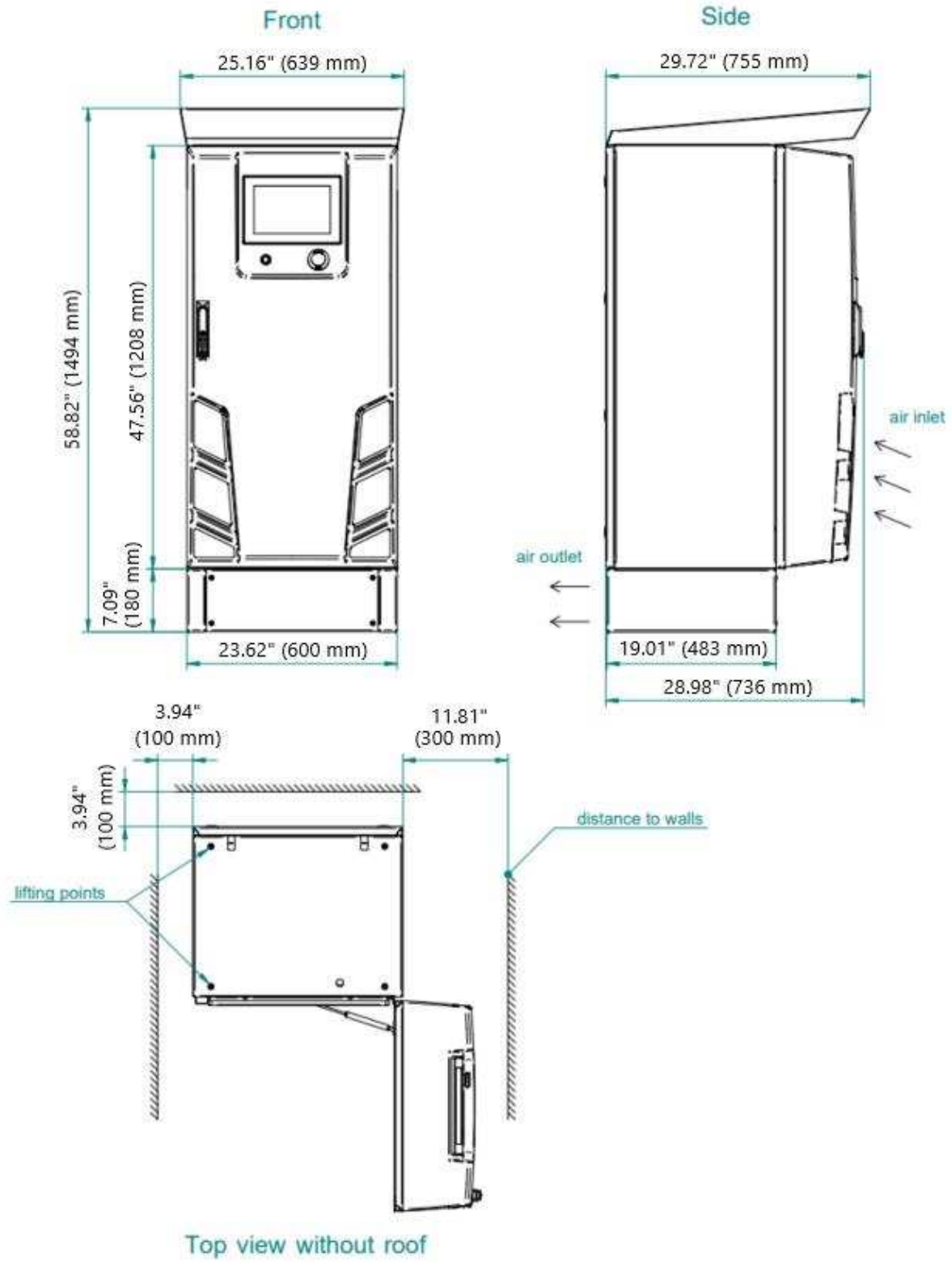
5.5 Billing

The utilisation of the GPU's can be evaluated in detail by displaying and processing certain states of operation (e.g. running hours per user, power consumption per user, etc.), which will be used as basis data for billing.

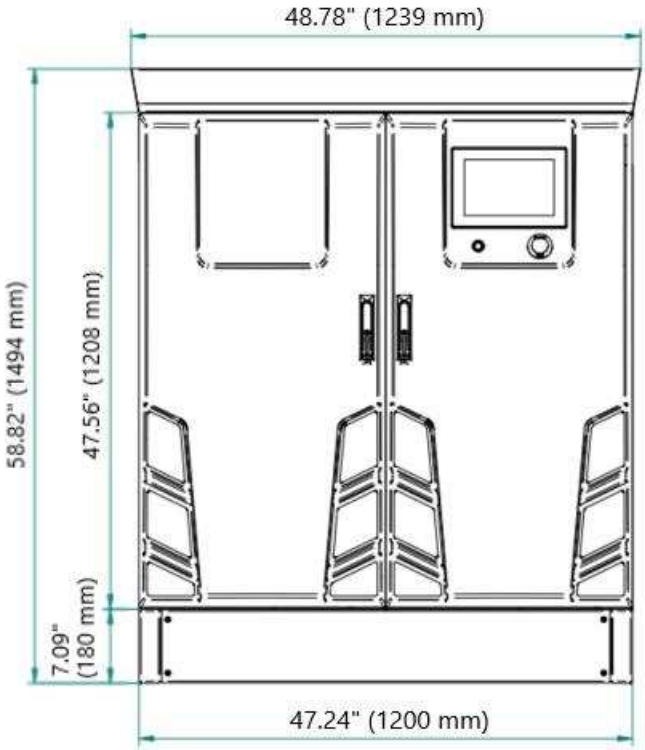
Furthermore, when using the GPU beyond a certain contractual condition, extra invoices to airlines or partners can be created fully automatically according to defined rules.

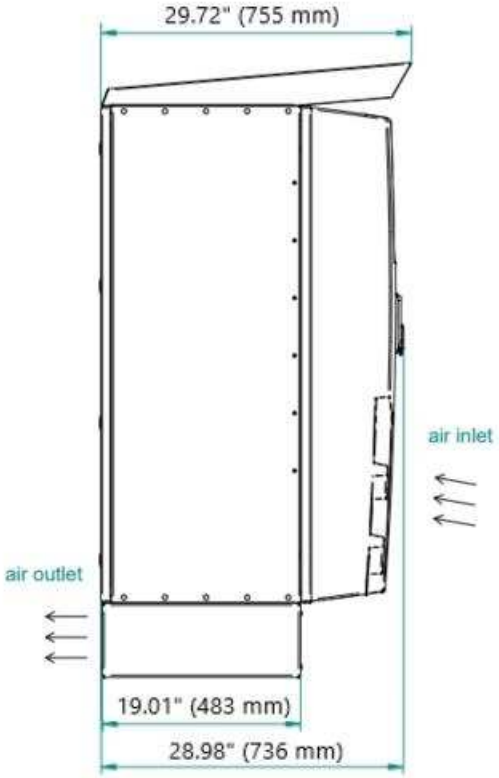
6 Dimensions

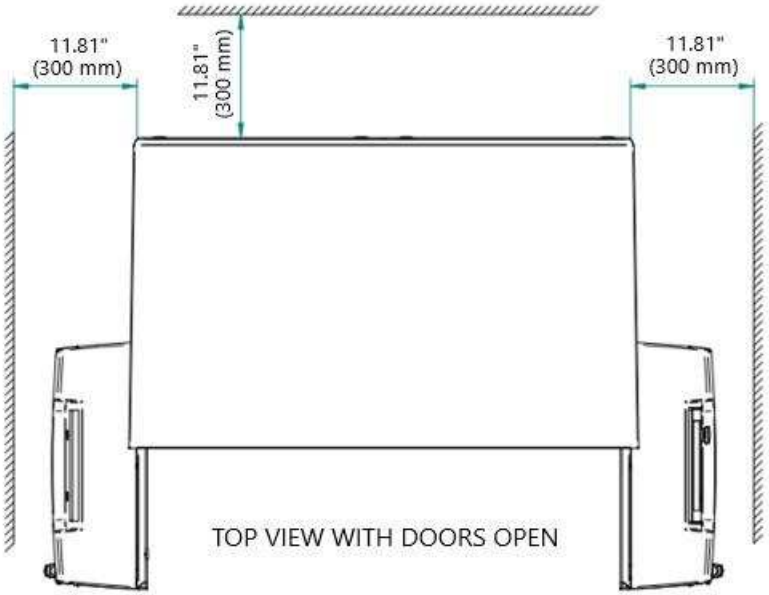
6.1 BPV



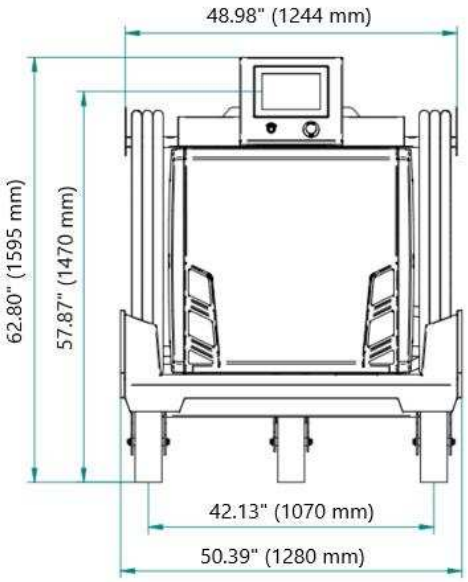
DIMENSIONS

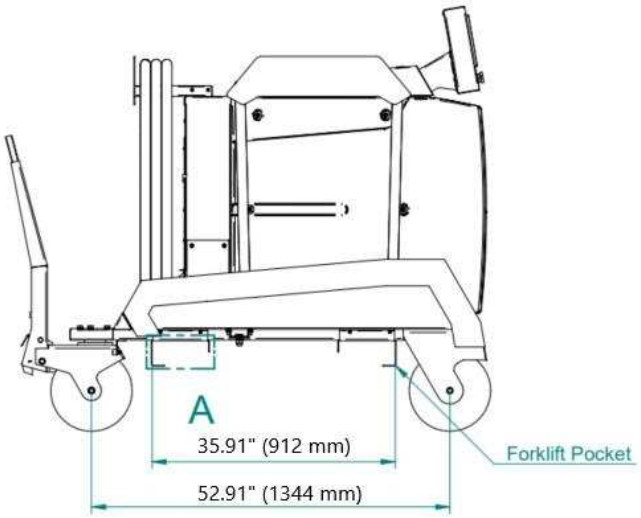

48.78" (1239 mm)
58.82" (1494 mm)
47.56" (1208 mm)
7.09" (180 mm)
47.24" (1200 mm)

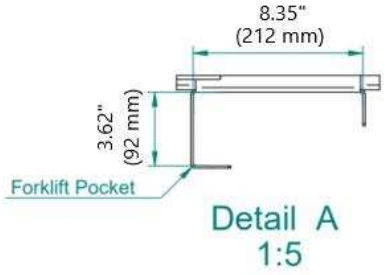

29.72" (755 mm)
air inlet
air outlet
19.01" (483 mm)
28.98" (736 mm)

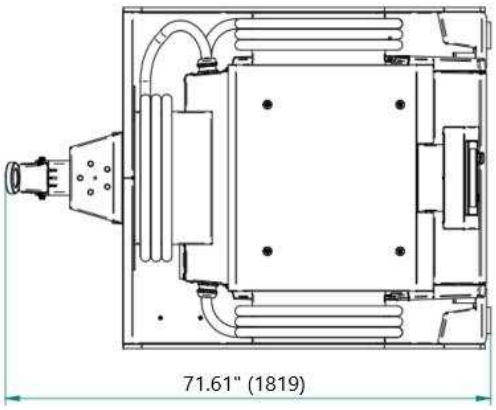

11.81" (300 mm)
11.81" (300 mm)
11.81" (300 mm)
TOP VIEW WITH DOORS OPEN

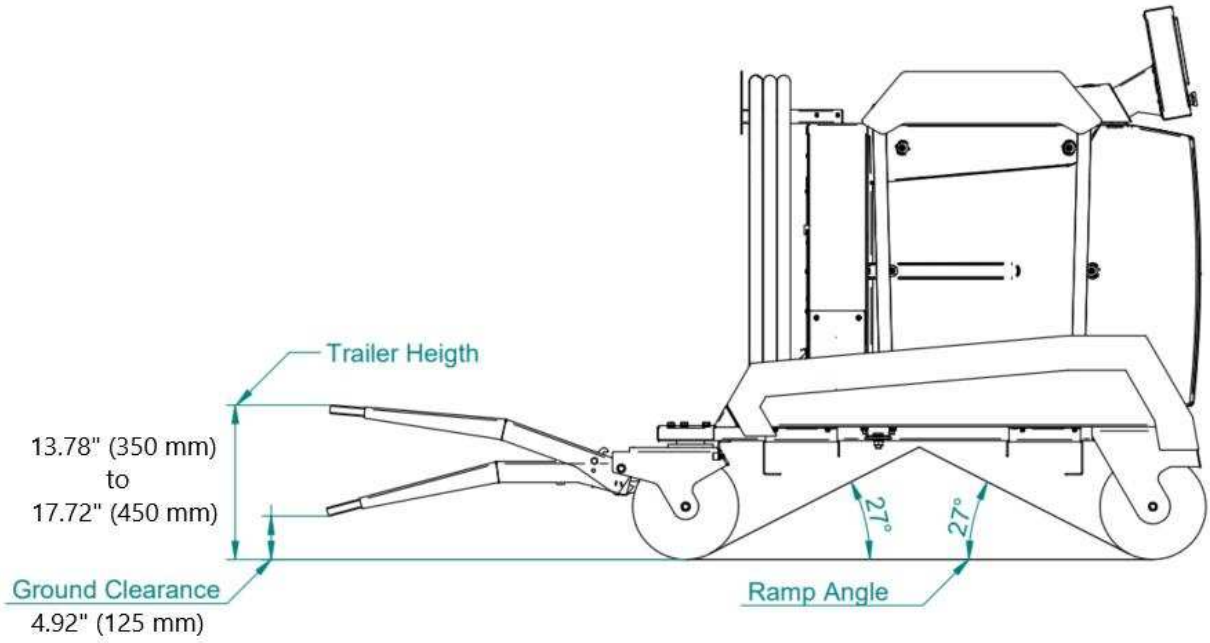
6.2 BPM-T

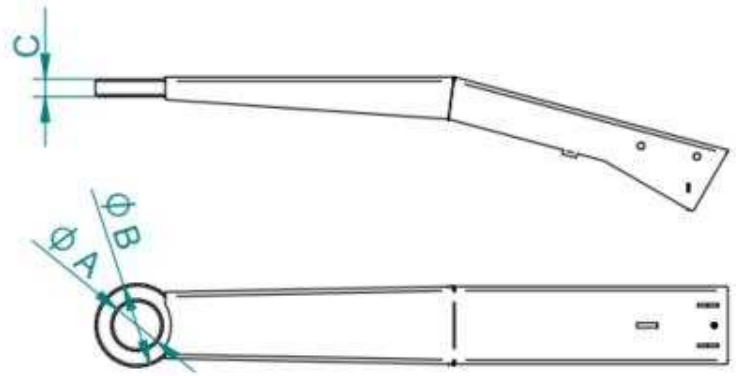

48.98" (1244 mm)
62.80" (1595 mm)
57.87" (1470 mm)
42.13" (1070 mm)
50.39" (1280 mm)


A
35.91" (912 mm)
52.91" (1344 mm)
Forklift Pocket


8.35"
(212 mm)
3.62"
(92 mm)
Forklift Pocket
Detail A
1:5


71.61" (1819)





Drawbar Eye			
drawbar	ØA	ØB	C
DIN40 drawbar	1.57" (40 mm)	3.94" (100 mm)	1.18" (30 mm)
Standard drawbar	2.68" (68 mm)	4.65" (118 mm)	0.98" (25 mm)
Nato drawbar	2.99" (76 mm)	6.30" (160 mm)	1.65" (42 mm)

6.3 BPH + BCH