SYSTEM OVERVIEW

KEY FEATURES

- Output Power: 10 kVA /10 kW
- DC & AC Output
- 3-Phase output (3 units)
- Four-quadrant operation
- Scalable up to 60 kW
- Programable V and I limits.
- Latency < 3 µs
  (Time between receiving the setpoint and changing the output)
- Voltage Slew Rate: 155 V/µs
- Max AC Output Voltage: 350 V_{RMS}
- Max AC Output Current: 32 A_{RMS}
- Max DC Output Voltage: 500 V
- Max DC Output Current: 40 A
- Large-signal BW: 50 kHz
- Small-signal BW: 100 kHz
- CE Certified

UHPS (**U**ltra **H**igh Bandwidth **P**HIL **S**ystem) is a galvanically isolated bidirectional 10 kVA / 10 kW emulation and test system developed and produced by EGSTON Power Electronics. It is capable of operating in single-phase AC mode or bipolar DC mode, as well as a wide range of user-defined HIL-based modes. Three-phase operation can be achieved using three synchronized UHPS units. The system can operate in current- or voltage-control mode, with seamless transition between sourcing and sinking power. When sinking, the power gets regenerated back to the supply grid.

Featuring large-signal bandwidth of **50 kHz** and small-signal bandwidth of **100 kHz**, the system can generate up to the 2000th order harmonics for a 50Hz fundamental or the 1666th order for a 60 Hz fundamental. Interharmonics up to 100 kHz can be generated for smooth frequency sweeps.

ECC-UHPS is a proprietary software developed by EGSTON Power to control, monitor and configure one or multiple UHPS units.

An **EGSTON App (4QAC or 4QDC)** or an **external Real-time Simulator** can provide the setpoints via a fast fiber-optic (SFP) interface as illustrated in figure 1. An integrated **function generator** can also provide setpoints, so a UHPS unit can operate as a high-frequency, low-latency 4Q AC or DC source out of the box.

System functionality and testing capabilities can be extended using EGSTON's 4-Quadrant source / sink applications and **PowerSCOPE,** a digital Oscilloscope developed specifically for the UHPS & COMPISO product ranges by EGSTON Power Electronics.

The 4QAC application enables UHPS to generate arbitrary periodic waveforms whose amplitude, frequency, phase (time shift) and DC offset can change every 1 ms. More complex test scenarios such as LVRT, HVRT and frequency drift can be defined using Scripter - an integrated development environment included with the application.

The 4QDC application enables various DC control modes on UHPS, ranging from constant-current, constant-voltage or constant-power operation to more advanced test cases such as internal resistance emulation, PV Array emulation, and battery modelling based on I-V curves. Battery impedance tests up to 100 kHz with a frequency resolution down to 1 mHz can be defined and customized using Scripter.

The PowerSCOPE application can be used to monitor system setpoints and generated voltages and currents, supporting visualization and storage of up to 32 input channels with a sample rate of 1 MS/s per channel.

SYSTEM DESCRIPTION

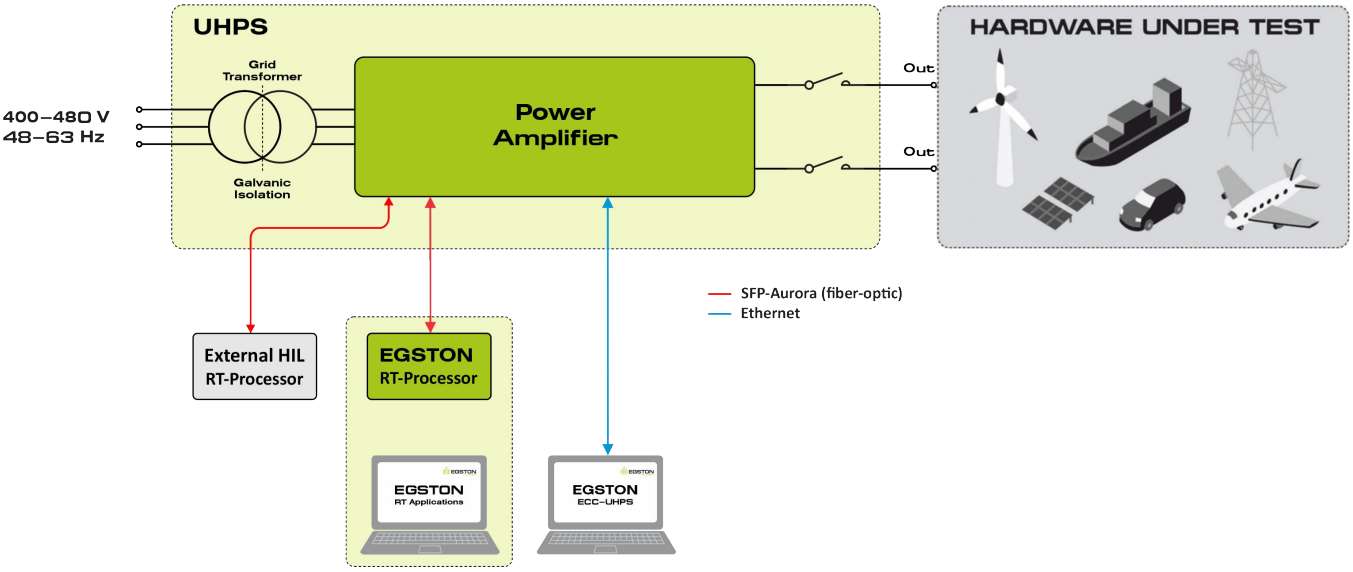


Figure 1. Simplified block diagram of the UHPS system.

UHPS can be powered by a three-phase AC power grid with a voltage ranging from 400 V to 480 V at 50 or 60 Hz. An internal transformer provides galvanic isolation between the Power Amplifier and the input power grid. Each output terminal has its own compact DC contactor to disconect the Device Under Test from UHPS.

The system can operate as a power source or sink, regenerating power back to the grid. The available voltage, current and power range in each operation mode are listed in Table 1, and are valid for both directions.

Table 1. Available voltage, current and power range in each operation mode

Operation mode		Single-phase AC	DC
Minimum Voltage	V_{min}	0 V_{RMS}	-500 V_{DC}
Maximum Voltage	V_{max}	353 V_{RMS}	500 V_{DC}
Minimum Current	I_{min}	0 A_{RMS}	-40 A_{DC}
Maximum Current	I_{max}	32 A_{RMS}	40 A_{DC}
Maximum Active Power	P_{max}	10 kW	10 kW
Maximum Apparent Power	S_{max}	10 kVA	
Nominal Voltage	V_{nom}	350 V_{RMS}	500 V_{DC}

TECHNICAL DATA: ELECTRICAL PROPERTIES

The electrical properties presented in Table 2 are valid for an ambient temperature of 25°C.

Table 2. Electrical properties

System properties		
System Rated Power	P_{OUT}	10 kW
System Overload for 60 s	P_{OUT_60s}	1.2 × P_{OUT} (in AC mode only)
System Overload for 2 s	P_{OUT_2s}	1.35 × P_{OUT} (in AC mode only)
System Efficiency	η	85% (at P_{OUT})
Output Harmonics range		Up to the 2000th (1666th) order harmonic at 50 (60) Hz fundamental Using the optional 4QAC application up to 1000 harmonics can be superimposed simultaneously on the fundamental frequency waveform.
Interharmonics and Subharmonics		Up to 50 kHz (full voltage), 50–100 kHz (reduced voltage)
Adjustable limits		Current, Voltage
Adjustable trips		Current, Voltage, Power
System protections		Overvoltage, Overcurrent, Short circuit, Overtemperature
Rated Insulation Voltage		1000 V_{DC} (output-to-ground)
Nominal Output Voltage		DC: 500 V_{DC} , AC: 350 V_{RMS}
Overvoltage Category		II
Protection Class		I
Degree of pollution		2
Equipment mobility		Floor standing on heavy duty, caster wheels with levelling feet
Certification		**CE**
Standards		
The product conforms with the following harmonized standards:		
Safety requirements		EN 61010-1:2010+A1:2019
EMC emission requirements		EN 55011:2016 + A1:2017
EMC immunity requirements		EN IEC 61000-6-2:2019
Regulations		
The product is compliant with the following European regulations:		
Low Voltage Directive		2014/35/EU
EMC Directive		2014/30/EU
RoHS Directive		2011/65/EU

Table 2 continued

System input properties		
Rated Input Power	S_{IN}	12 kVA
Rated Input Voltage	V_{AC}	400 V_{RMS} ±10% (or 480 V_{RMS} ±10%)
Input frequency range	f	47,5–63 Hz
Rated Input Current	I_{IN}	17.5 A_{RMS} (for 400 V_{RMS} input), 14.5 A_{RMS} (for 480 V_{RMS} input)
Inrush Current	I_{INRUSH}	40 Apeak
Power factor	PF	≈1
Input Current THD	THDi	< 5% (at rated power)
Suggested External Fuse Rating		3x20 A / Characteristic: aG
Minimum input cable cross section		5x2.5 mm^2
Cable Connection Type: (eg 4X terminals, M10)		4x Screw connection with tension sleeve, 1 Not connected
Input cable diameter range:		13 mm – 18 mm
Input cable gland tightening torque:		17 Nm ± 1 Nm
System output properties		
Output freq. large signal	f_{OUT_LS}	0,1 Hz to 50 kHz
Output freq. small signal	f_{OUT_SS}	0,1 Hz to 100 kHz
Output frequency resolution		±1 mHz
Output Voltage THD	THDu	< 1% at 50/60 Hz without load < 1% at 400 Hz without load
Effective switching frequency	f_{SW}	2400 kHz
Delay time (typical)	t_d	3 µs (setpoint-to-output)
Voltage slew rate	SR	155 V/µs (maximum slew rate of the output voltage with a resistive load)
Output connection type		2x Screw connection with tension sleeve
Output wire diameter range:		6 mm – 9 mm
Minimum Output Wire Cross Section:		10 mm^2
Input cable gland tightening torque:		3.5 Nm
Output contactors		
Utilization category		DC-1 (according to IEC/EN 60947-4-1)
Rated operational Voltage	U_e	1000 V_{DC}
Rated insulation Voltage	U_i	1000 V_{DC}
Rated operational Current	I_e	200 A
Making capacity		500 A
Breaking capacity		500 A
Lifespan, mechanical		10^6 operations (in AC or DC)

Table 2 continued

Measurement Properties	
Voltage measurement range	±715 V (DC or AC peak)
Voltage measurement accuracy	±1 V (0.14 % of measurement range)
Current measurement range	±50 A (DC or AC peak)
Current measurement accuracy	±0,35 A (0,7 % of measurement range)
Measurement resolution	12 bits
Measurement sample rate	100 MS/s (per channel)
Measurement bandwidth	0 – 250 kHz (-3 dB)

The basic properties of the communication protocols and interfaces supported by the UHPS are presented in Table 3.

Table 3. Communication protocols and interfaces supported by the UHPS

SFP–HIL ultra-high-speed interface	
Digital RT communication between UHPS and an external HIL RT processor (or an EGSTON RT Processor) over fiber-optic cable. Receives voltage or current setpoints and transmits measured voltages and currents.	
Data rate	5 Gbps
Latency	≤ 0,5 µs
Setpoint time step	1 µs
Setpoint update frequency	1 MHz
SFP–UDP	
Digital RT data transfer from UHPS to EGSTON PowerSCOPE, transmitting measured voltages, currents and setpoints set via the SFP–HIL to the EGSTON RT-Processor.	
Data rate	1 Gbps (1000BASE-T)
Ethernet interface (non-RT communication among UHPS, ECC and EGSTON power applications PC)	
Transmission protocol	TCP
Data rate	100 Mbps
Recommended Ethernet cable category	CAT 6a or better

SUPPORTED COMMERCIAL HIL PLATFORMS

Table 4. Supported commercial HIL platforms.

Supported commercial HIL platforms	
SFP interface	• OPAL-RT • National Instruments • RTDS Technologies • Speedgoat • dSpace • Typhoon

TECHNICAL DATA: AMBIENT AND COOLING

Technical data on the ambient conditions and cooling requirements is presented in Table 5.

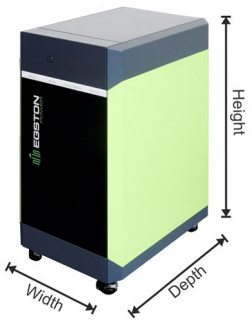
Table 5. Ambient conditions and cooling requirements

Ambient conditions	
Operating Temperature	5–30°C
Relative Humidity (non-condensing)	90%
Maximum Altitude	2000 m
Ingress protection	IP20 (per IEC 60529)
Noise level (sound pressure level)	< 70 dB (at operator's normal position and bystanders' positions)
Forced-air cooling	
Rated air-cooling power	1.9 kW_{th} (at 10 kW output power)

TECHNICAL DATA: MECHANICAL PROPERTIES

The dimensions and weight of the UHPS cabinet are listed in Table 6.

Table 6. Dimensions and weight of the UHPS cabinet

Width		Depth		Height (incl. rollers)		Weight		
mm	ft	mm	ft	mm	ft	kg	lb	
604	1' 11 $^{25}/_{32}$"	826	2' 8 $^{33}/_{64}$"	1085	3' 6 $^{23}/_{32}$"	Approx. 350	Approx. 770	

UHPS SINGLE-PHASE / DC OPERATION

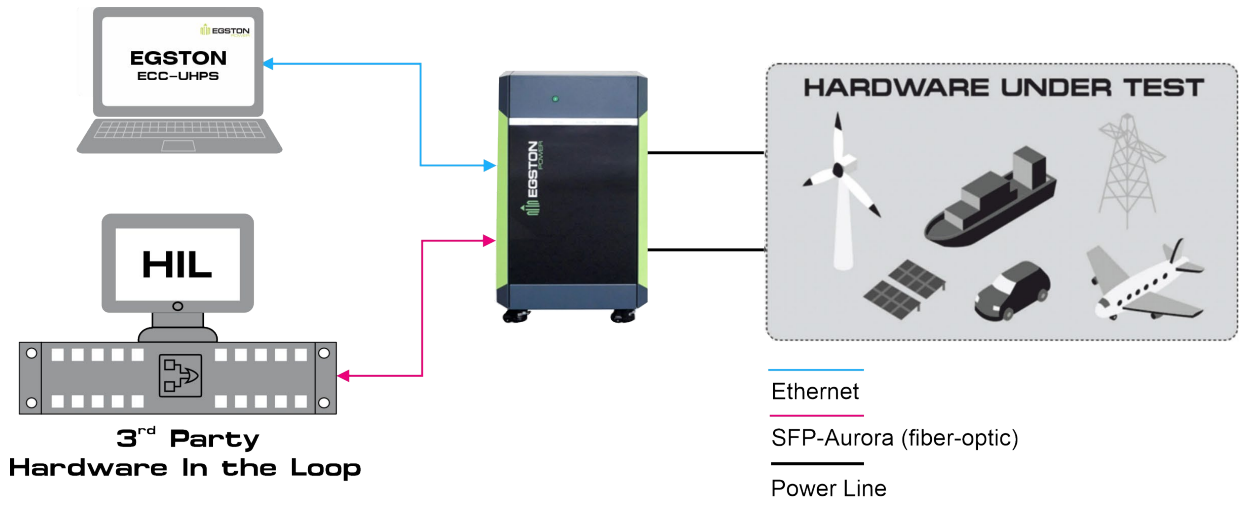


Figure 2. Simplified block diagram of UHPS Single phase / DC Operation.

UHPS THREE-PHASE OPERATION

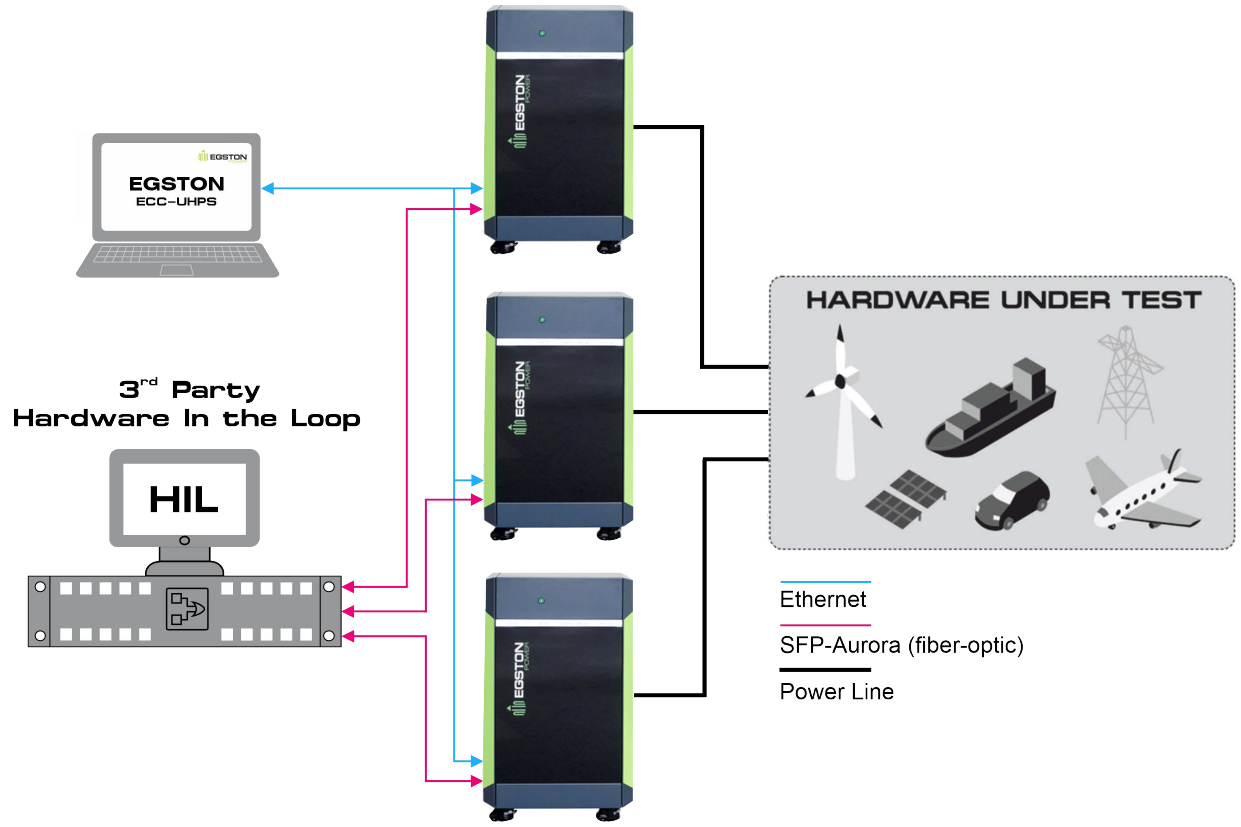


Figure 3. Simplified block diagram of UHPS 3-Phase Operation.

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