ELECTRONIC TEST & POWER SYSTEMS

G5-SOURCE-HC

MODULAR HIGH CURRENT DC SOURCES

POSITIVE PROBLEM SOLVING

With the ability to source high currents up to tens of kiloamps, the G5-SOURCE-HC is ideal for short-circuit testing, pulsing applications and powering electromagnets. Modules are stackable to 5MW.

Each module has an extensive feature set which includes programmable PI parameters and an inbuilt 8 channel recording scope. Adjustable power and resistance limits are provided. Optional remote control interfaces are available including high-speed CAN. Every G5-SOURCE-HC features an autoranging output, which allows for many more V/I combinations at nominal power. Modules can be fitted into flight cases or lab racks, with available options including isolation monitoring and emergency stops.

- + Programmable Ripple up to 10kHz
- + Two Current Ranges for Higher Accuracy
- + Mixed Power Nominals in Master-Slave
- + Optional Battery Emulation Software
- + Ultra-Fast Dynamic Behaviour
- + Voltages up to 1280V

CONTENTS

STANDARD MODELS

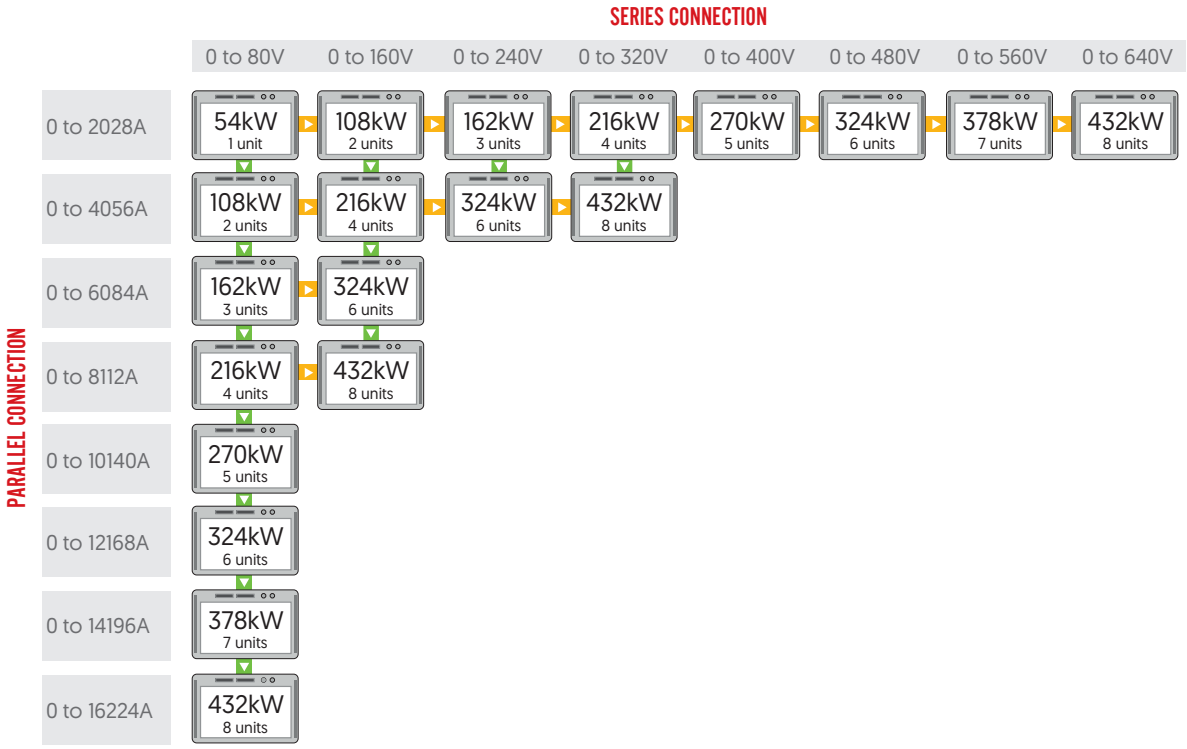
SELECTION TABLE

Part Number	Maximum Power	Q1 Source Voltage	Current Range	Internal Resistance Range
G5-SOURCE 9-80-338	9kW	0 to 80Vdc	0 to 338A	0 to 473mΩ
G5-SOURCE 18-80-676	18kW	0 to 80Vdc	0 to 676A	0 to 237mΩ
G5-SOURCE 18-160-338	18kW	0 to 160Vdc	0 to 338A	0 to 947mΩ
G5-SOURCE 27-80-1014	27kW	0 to 80Vdc	0 to 1014A	0 to 158mΩ
G5-SOURCE 27-240-338	27kW	0 to 240Vdc	0 to 338A	0 to 1420mΩ
G5-SOURCE 36-80-1352	36kW	0 to 80Vdc	0 to 1352A	0 to 118mΩ
G5-SOURCE 36-160-676	36kW	0 to 160Vdc	0 to 676A	0 to 473mΩ
G5-SOURCE 36-320-338	36kW	0 to 320Vdc	0 to 338A	0 to 1893mΩ
G5-SOURCE 45-80-1690	45kW	0 to 80Vdc	0 to 1690A	0 to 95mΩ
G5-SOURCE 54-80-2028	54kW	0 to 80Vdc	0 to 2028A	0 to 79mΩ
G5-SOURCE 54-160-1014	54kW	0 to 160Vdc	0 to 1014A	0 to 316mΩ
G5-SOURCE 54-240-676	54kW	0 to 240Vdc	0 to 676A	0 to 710mΩ

MODULARITY (MASTER/SLAVE)

G5-SOURCE-HC modules can be arranged in series, parallel or matrix array configurations up to 5MW. Each module is able to operate independently. It is possible to connect models with different nominal powers in an asymmetric parallel or series configuration, as long as each module has the same nominal voltage. For example, an 18kW/80V/675A and 54kW/80V/2028A module can be connected together to in parallel to create a 72kW/80V/2703A system.

The modular approach is useful for test houses and research labs who regularly test different sized power devices. The diagram shows all the possible combinations with eight 54kW/80V modules.



OPTIONS TABLE

OPTIONS

CODE	DESCRIPTION
	FORM FACTOR AND ENCLOSURES
/LR	Integration into a 19" lab rack
/FC	Integration into a flightcase
	INPUT
/FILTER	Input air filter
	INTERFACES AND CONTROL
/HMI	Touchscreen HMI providing front panel control and measurement
/CANMP	Integrated CANmp interface
/ETHERCAT	EtherCAT interface
	SOFTWARE/SOFT TOOLS
/TFE	Integrated function generating engine for time based programming
/AAP	Integrated function generating engine with application area (parametric) programming
/BATSIM	GUI simulating battery characteristics with adjustable parameters
/BATCONTROL	Energy storage and drive cycling GUI
/SASCONTROL	Solar array simulation GUI (includes /AAP option)
	SAFETY AND PROTECTION
/ISR	Integrated safety relay for shutdown to EN 13849-1 Cat 2/3
/RPP	Automatic voltage matching with reverse polarity protection
/PACOB	Touchproof protective cover for AC and DC terminals (9kW and 18kW units only), mandatory for tabletop use
/XCD	A safety discharge circuit which quickly removes a residual voltage hazard from the module within 1s, should the plug be accidentally removed while the G5-SOURCE-HC is energised
/SELV	60V model featuring the same technical specifications as a selected 80V unit, with additional safety features to meet SELV requirements (Separated Extra Low Voltage)

FORM FACTOR AND ENCLOSURES

STANDARD FEATURES

TECHNICAL DATA	
Module Dimensions	19" × 673mm (W × D) without terminals, a full cabinet integration service is available on request
Module Height	4U (9kW/18kW models), 7U (27kW/36kW models), 10U (45kW/54kW models)
Weight	44kg (9kW models), 52kg (18kW models), 84kg (27kW models), 92kg (36kW models), 124kg (45kW models), 132kg (54kW models)
Basic Construction	IP 20 (up to IP 54 when mounted in a cabinet)

Each G5-SOURCE-HC is built into a 19" rackmounting case as standard. Units can be treated to a laboratory rack or flight case integration. Common options include mains cables, passive indication of any residual DC voltage, isolation monitoring of DC cables and a panel mounted emergency stop. Switch panels can be fitted for certain models. This simplifies the reconfiguration between series, parallel or independent use. Simple wheeled cabinets are also available.

4U 9kW/18kW MODULES

7U 27kW/36kW MODULES

10U 45KW/54kW MODULES

216kW CABINET INTEGRATION

OPERATING RANGES AND FEATURES

STANDARD FEATURES

	G5-SOURCE 09-80-338	G5-SOURCE 18-80-676	G5-SOURCE 18-160-338	G5-SOURCE 27-80-1014	G5-SOURCE 27-240-338	G5-SOURCE 36-80-1352
Remote Voltage Sense	Programmable (stability/drift: ≤0.01%FS[4] | temperature coefficient: 0.007%FS/°C[5])					
Stability/Drift	Voltage: ≤0.01%FS[4] | Current: ≤0.01%FS[4]					
Temperature Coefficient	Voltage: 0.005%FS/°C[5] | Current: 0.005%FS/°C[5]					
Efficiency	94% at P_{MAX}/V_{MAX}, 92% at P_{MAX}/I_{MAX}					
Rise/Fall Time[6]: 10% to 90% of Step (0 to 90% V_{MAX}/ 90% P_{MAX})	≤220µs					
Rise/Fall Time[6]: 10% to 90% of Step (0 to 33% V_{MAX}/ 30% P_{MAX})	≤155µs	≤155µs	≤160µs	≤160µs	≤160µs	≤160µs
Rise/Fall Time[7]: 10% to 90% of Step (10% to 90% I_{MAX} at 33% V_{MAX}) 10% to 90% of step at low inductance	30µs	50µs	30µs	50µs	25µs	50µs
Transient Response Time[8] (CV, Recovery Within 2% of Set Voltage)	50µs	50µs	50µs	50µs	50µs	50µs
Transient Response Time[9] (CV, Recovery Within 0.5% of Set Voltage)	≤50µs	≤50µs	≤50µs	≤50µs	≤50µs	≤50µs
Transient Response Time[10] (CC, Recovery Within 2% of Set Current)	≤230µs	≤290µs	≤510µs	≤230µs	≤550µs	≤270µs
Voltage Drop While Load Switching On (45% to 90% P_{MAX} at 90% V_{MAX} at rate 675A/100µs in HighCap mode)	4V	6.5V	4.5V	8V	4.5V	8.5V
Voltage Overshoot While Load Switching Off (90% to 45% P_{MAX} at 90% V_{MAX} at rate 675A/100µs in HighCap mode)	4V	6.5V	4V	8V	4.5V	8.5V
Output Capacitance: X-capacitor LowCap	530µF	1060µF	265µF	1590µF	177µF	2120µF
Output Capacitance: X-capacitor HighCap	12410µF	24820µF	6205µF	37230µF	4137µF	49640µF
Output Capacitance: Y-capacitor at DC	163nF	158nF	195nF	222nF	226nF	263nF
Ripple: Output Voltage Ripple (4.1kHz to 3.8MHz): Vrms, LowCap, Ohmic Load, 90% P_{MAX} 90% V_{MAX}, CV Mode	≤0.2% FS	≤0.2% FS	≤0.15% FS	≤0.15% FS	≤0.2% FS	≤0.15% FS
Ripple: Output Voltage Ripple (4.1kHz to 3.8MHz): Vrms, HighCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.15% FS	≤0.15% FS	≤0.15% FS	≤0.15% FS	≤0.2% FS	≤0.15% FS
Ripple: Output Current Ripple (4.1kHz to 3.8MHz): Arms, LowCap, Ohmic Load, 90% P_{MAX}, CC Mode	≤0.06% FS at 90% I_{MAX}	≤0.02% FS at 66% I_{MAX}	≤0.05% FS at 90% I_{MAX}	≤0.04% FS at 90% I_{MAX}	≤0.1% FS at 90% I_{MAX}	≤0.02% FS at 46% I_{MAX}
Noise: (10Hz to 3.8MHz) : Vpp, LowCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.9% FS	≤0.8% FS	≤0.6% FS	≤0.6% FS	≤0.9% FS	≤0.6% FS
Noise: (10Hz to 3.8MHz) : Vpp, HighCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.6% FS	≤0.7% FS	≤0.5% FS	≤0.6% FS	≤0.8% FS	≤0.7% FS

[1] At 25°C ambient temperature, constant line conditions. [2] With a constant resistive load in LowCap mode.
[3] Constant voltage mode, recovery within 0.5% SetValue at 30% V_{MAX}/100% V_{MAX}, with a resistive load in HighCap mode.
[4] 8h after 1h warm up time at constant line input, load and temperature. [5] At constant line and load conditions.
[6] Voltage set-value step, constant ohmic load, LowCap mode. [7] Current set-value step, constant voltage, LowCap mode.
[8] 0 to 90% P_{MAX} load step at 90% V_{MAX}. Assuming an ohmic load in HighCap mode.
[9] 45 to 90% P_{MAX} load step at 90% V_{MAX}. Assuming an ohmic load in HighCap mode.
[10] 45 to 90% P_{MAX} load step at 90% I_{MAX}. Assuming an ohmic load in LowCap mode.

OPERATING RANGES AND FEATURES

STANDARD FEATURES

	G5-SOURCE 09-80-338	G5-SOURCE 18-80-676	G5-SOURCE 18-160-338	G5-SOURCE 27-80-1014	G5-SOURCE 27-240-338	G5-SOURCE 36-80-1352
HMI Touchpanel Meter Resolution	0.01V/0.01A	0.01V/0.01A	0.01V/0.01A	0.01V/0.1A	0.01V/0.01A	0.01V/0.1A
Output Discharge to <60V	Active discharge enabled: ≤1s Active discharge disabled: <60s					
Static Accuracy[11]: Power at I_{MAX} 1kHz Filter	0.04% FS	0.05% FS	0.04% FS	0.06% FS	0.04% FS	0.07% FS
Static Accuracy[11]: Voltage	0.02% FS	0.02% FS	0.015% FS	0.02% FS	0.015% FS	0.02% FS
Static Accuracy[11]: Voltage Sense	0.02% FS	0.02% FS	0.015% FS	0.02% FS	0.015% FS	0.02% FS
Static Accuracy[11]: Current Full Range 1kHz Filter	0.03% FS	0.04% FS	0.03% FS	0.05% FS	0.03% FS	0.065% FS
Static Accuracy[11]: Resistance at I_{MAX} 1kHz Filter	0.035% FS	0.045% FS	0.035% FS	0.055% FS	0.035% FS	0.065% FS
Small Signal Modulation (Voltage Controller LowCap Mode)	Frequency (CV, CC): 0 to 10kHz Modulation range V_{RMS} sine at 10kHz: 0 to 5% FS Attenuation at 5kHz/10kHz, operating point: 90% V_{NOM} +5% V_{NOM} amplitude: 0.4dB/5.6dB (80V Models), -0.2dB/5.8dB (160V Models), 0.2dB/6dB (240V Models) Phase lag analogue input to voltage out: 130µs					
Small Signal Modulation (Current Controller LowCap Mode)	Modulation range A_{RMS} sine at 10kHz: 0 to 5% FS Phase lag analogue input to current out: 145µs (80V Models), 140µs (160V/240V Models)					
Sense Input Impedance While Operational	196kΩ	196kΩ	395kΩ	196kΩ	595kΩ	196kΩ
Sense Input Impedance - Voltage OFF	196kΩ	196kΩ	395kΩ	196kΩ	595kΩ	196kΩ
Sense Input Impedance - Voltage OFF (Output Measurement Disconnected)	Open					
Ballast Resistor DC Power Port at Voltage OFF (no /RPP Option or RPP Closed)	2.9kΩ	1.45kΩ	5.4kΩ	890Ω	8kΩ	632Ω

[11] At 25° ambient temperature, constant line/load conditions normal distribution (k=2).

OPERATING RANGES AND FEATURES

STANDARD FEATURES

	G5-SOURCE 36-160-676	G5-SOURCE 36-320-338	G5-SOURCE 45-80-1690	G5-SOURCE 54-80-2028	G5-SOURCE 54-160-1014	G5-SOURCE 54-240-676
Remote Voltage Sense	Programmable (stability/drift: ≤0.01%FS[4] | temperature coefficient: 0.007%FS/°C[5])					
Stability/Drift	Voltage: ≤0.01%FS[4] | Current: ≤0.01%FS[4]					
Temperature Coefficient	Voltage: 0.005%FS/°C[5] | Current: 0.005%FS/°C[5]					
Efficiency	94% at P_{MAX}/V_{MAX}, 92% at P_{MAX}/I_{MAX}					
Rise/Fall Time[6]: 10% to 90% of Step (0 to 90% V_{MAX}/ 90% P_{MAX})	≤220µs					
Rise/Fall Time[6]: 10% to 90% of Step (0 to 33% V_{MAX}/ 30% P_{MAX})	≤165µs	≤160µs	≤160µs	≤170µs	≤160µs	≤160µs
Rise/Fall Time[7]: 10% to 90% of Step (10% to 90% I_{MAX} at 33% V_{MAX}) 10% to 90% of step at low inductance	30µs	50µs	60µs	60µs	50µs	50µs
Transient Response Time[8] (CV, Recovery Within 2% of Set Voltage)	50µs	50µs	50µs	50µs	50µs	50µs
Transient Response Time[9] (CV, Recovery Within 0.5% of Set Voltage)	≤50µs	≤50µs	≤50µs	≤230µs	≤50µs	≤50µs
Transient Response Time[10] (CC, Recovery Within 2% of Set Current)	≤270µs	≤560µs	≤300µs	≤320µs	≤290µs	≤280µs
Voltage Drop While Load Switching On (45% to 90% P_{MAX} at 90% V_{MAX} at rate 675A/100µs in HighCap mode)	6.5V	4.5V	8.5V	8.5V	8V	7V
Voltage Overshoot While Load Switching Off (90% to 45% P_{MAX} at 90% V_{MAX} at rate 675A/100µs in HighCap mode)	6.5V	4.5V	8.5V	8.5V	8V	7V
Output Capacitance: X-capacitor LowCap	530µF	265µF	2650µF	3180µF	795µF	353µF
Output Capacitance: X-capacitor HighCap	12410µF	6205µF	62050µF	74460µF	18615µF	8273µF
Output Capacitance: Y-capacitor at DC	259nF	256nF	291nF	327nF	322nF	330nF
Ripple: Output Voltage Ripple (4.1kHz to 3.8MHz): Vrms, LowCap, Ohmic Load, 90% P_{MAX} 90% V_{MAX}, CV Mode	≤0.1% FS	≤0.2% FS	≤0.2% FS	≤0.15% FS	≤0.15% FS	≤0.1% FS
Ripple: Output Voltage Ripple (4.1kHz to 3.8MHz): Vrms, HighCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.1% FS	≤0.2% FS	≤0.2% FS	≤0.15% FS	≤0.1% FS	≤0.1% FS
Ripple: Output Current Ripple (4.1kHz to 3.8MHz): Arms, LowCap, Ohmic Load, 90% P_{MAX}, CC Mode	≤0.05% FS at 90% I_{MAX}	≤0.1% FS at 90% I_{MAX}	≤0.05% FS at 58% I_{MAX}	≤0.02% FS at 38% I_{MAX}	≤0.1% FS at 90% I_{MAX}	≤0.1% FS at 90% I_{MAX}
Noise: (10Hz to 3.8MHz) : Vpp, LowCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.4% FS	≤0.75% FS	≤0.9% FS	≤0.7% FS	≤0.6% FS	≤0.5% FS
Noise: (10Hz to 3.8MHz) : Vpp, HighCap, Ohmic Load, 90% P_{MAX}, 90% V_{MAX}, CV Mode	≤0.4% FS	≤0.7% FS	≤0.9% FS	≤0.6% FS	≤0.5% FS	≤0.4% FS

[1] At 25°C ambient temperature, constant line conditions. [2] With a constant resistive load in LowCap mode.
[3] Constant voltage mode, recovery within 0.5% SetValue at 30% V_{MAX}/100% V_{MAX}, with a resistive load in HighCap mode.
[4] 8h after 1h warm up time at constant line input, load and temperature. [5] At constant line and load conditions.
[6] Voltage set-value step, constant ohmic load, LowCap mode. [7] Current set-value step, constant voltage, LowCap mode.
[8] 0 to 90% P_{MAX} load step at 90% V_{MAX}. Assuming an ohmic load in HighCap mode.
[9] 45 to 90% P_{MAX} load step at 90% V_{MAX}. Assuming an ohmic load in HighCap mode.
[10] 45 to 90% P_{MAX} load step at 90% I_{MAX}. Assuming an ohmic load in LowCap mode.

OPERATING RANGES AND FEATURES

STANDARD FEATURES

	G5-SOURCE 36-160-676	G5-SOURCE 36-320-338	G5-SOURCE 45-80-1690	G5-SOURCE 54-80-2028	G5-SOURCE 54-160-1014	G5-SOURCE 54-240-676
HMI Touchpanel Meter Resolution	0.01V/0.01A	0.01V/0.01A	0.01V/0.1A	0.01V/0.1A	0.01V/0.1A	0.01V/0.01A
Output Discharge to <60V	Active discharge enabled: ≤1s Active discharge disabled: <60s					
Static Accuracy[11]: Power at I_{MAX} 1kHz Filter	0.05% FS	0.04% FS	0.08% FS	0.09% FS	0.06% FS	0.05% FS
Static Accuracy[11]: Voltage	0.015% FS	0.01% FS	0.02% FS	0.02% FS	0.015% FS	0.015% FS
Static Accuracy[11]: Voltage Sense	0.015% FS	0.01% FS	0.02% FS	0.02% FS	0.015% FS	0.015% FS
Static Accuracy[11]: Current Full Range 1kHz Filter	0.04% FS	0.03% FS	0.075% FS	0.085% FS	0.05% FS	0.04% FS
Static Accuracy[11]: Resistance at I_{MAX} 1kHz Filter	0.045% FS	0.03% FS	0.08% FS	0.085% FS	0.055% FS	0.04% FS
Small Signal Modulation (Voltage Controller LowCap Mode)	Frequency (CV, CC): 0 to 10kHz Modulation range V_{RMS} sine at 10kHz: 0 to 5% FS Attenuation at 5kHz/10kHz, operating point: 90% V_{NOM} +5% V_{NOM} amplitude: 0.4dB/5.6dB (80V Models), -0.2dB/5.8dB (160V Models), 0.2dB/6dB (240V Models), 0.1dB/6.1dB (320V Models) Phase lag analogue input to voltage out: 130µs					
Small Signal Modulation (Current Controller LowCap Mode)	Modulation range A_{RMS} sine at 10kHz: 0 to 5% FS Phase lag analogue input to current out: 145µs (80V Models), 140µs (160V/240V/320V Models)					
Sense Input Impedance While Operational	395kΩ	805kΩ	196kΩ	196kΩ	395kΩ	595kΩ
Sense Input Impedance - Voltage OFF	395kΩ	805kΩ	196kΩ	196kΩ	395kΩ	595kΩ
Sense Input Impedance - Voltage OFF (Output Measurement Disconnected)	Open					
Ballast Resistor DC Power Port at Voltage OFF (no /RPP Option or RPP Closed)	2.9kΩ	10.6kΩ	512Ω	443Ω	1.95kΩ	4.25kΩ

[11] At 25° ambient temperature, constant line/load conditions normal distribution (k=2).

OPERATING RANGES AND FEATURES

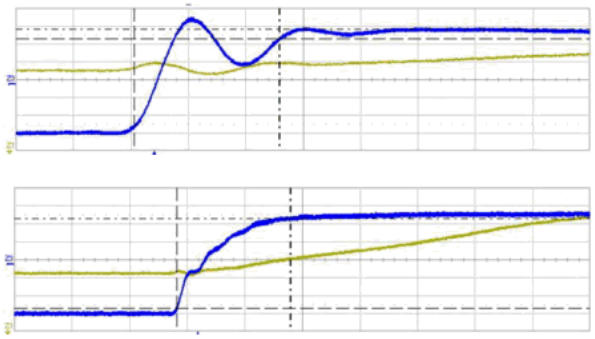
HIGHLIGHTED FEATURES

SENSE COMPENSATION

Sense plus terminals are built into the G5-SOURCE-HC for the connection of sense wire which compensates for voltage drops in the load lines. This has a number of advantages over traditional sense. It is permitted to interrupt the load line during operation (voltage on). The maximum voltage drop compensation is adjustable. The voltage difference between G5-SOURCE-HC output and sensing point is monitored. If a set limit is exceeded, the G5-SOURCE-HC unit shuts off. This is particularly useful for applications with long cables often prone to unwanted voltage drops.

FAST DYNAMICS AND HIGH STABILITY

A current step between 90% to 0% I_{MAX} can be as quick as 50µs, enabling high speed drives to be supplied. Advanced users have access to the controller settings enabling the response to be optimised for particular loads. This example shows a current step through quadrants. The upper trace shows the current transition is achieved in 50µs with a small overshoot before settling. The lower plot shows a more regulated response within 200µs. Voltage typically takes 100µs to recover within 0.5% of the set value. In multi-module systems the communication time between modules need to be considered.



SECOND CURRENT RANGE

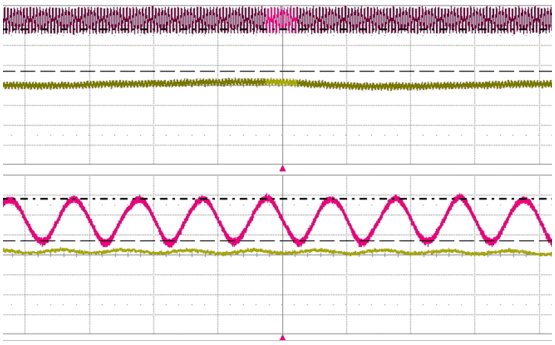
Each module features a second current range that can be built into systems to give better accuracy and resolution for low current applications. This is particularly useful when testing high voltage equipment, such as electric vehicle battery packs, which typically produce low currents.

SWITCHABLE OUTPUT CAPACITANCE

Switchable capacitance is provided within each G5-SOURCE-HC module as standard and is used to optimise the DC filter depending on the application in which the systems are used. A low capacitance level provides fast dynamics in constant current when charging/ discharging/ cycling energy storage devices. Switching to the higher cap value provides for smoother operation during hard load steps when operating in constant voltage. Typical applications include energy storage simulation for electric drive developments.

PROGRAMMABLE RIPPLE

By utilising the optional embedded function generator the user can set a current ripple at up to 10kHz. The magnitude can be up to 5% of the nominal system current. Depending on the impedance of the DUT the resulting voltage ripple can be calculated. The below example shows a 10kHz ripple generated using the function generator of the G5-SOURCE-HC. A peak to peak current of 8A has been superimposed on a current of 100A. Alternatively, a ripple can be implemented from an external waveform generator via the analogue interface using a proportional 0-10V signal.

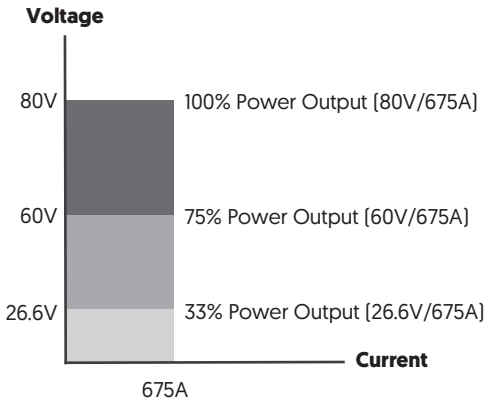


AUTORANGING CAPABILITY

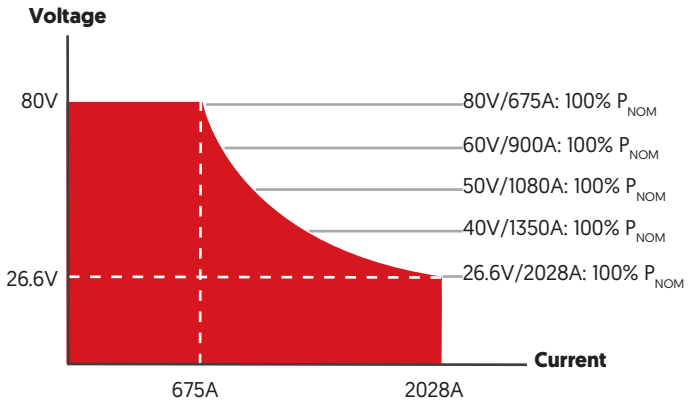
Every G5-SOURCE-HC features an autoranging output. This allows many more voltage/current combinations at nominal power than a traditional DC power supply. An example of the difference is shown below using a G5-SOURCE-HC 54-80-2028.

Using one autoranging DC source instead of several traditional power systems saves both cost and bench space. Despite the units offering such a large output range, they are still incredibly power dense. 54kW of output power is provided from 10U of rackmounting height.

TRADITIONAL 54kW/80V SYSTEM



G5-SOURCE-HC 54kW/80V SYSTEM



OPERATING MODES

STANDARD FEATURES

	G5-SOURCE 09-80-338	G5-SOURCE 18-80-676	G5-SOURCE 18-160-338	G5-SOURCE 27-80-1014	G5-SOURCE 27-240-338	G5-SOURCE 36-80-1352
Operating Modes	Constant Voltage (0 to 100% of V_{MAX}) Constant Current (0 to 100% of I_{MAX}) Constant Power (5% to 100% of P_{MAX})					
Internal Resistance Range	0 to 473mΩ	0 to 237mΩ	0 to 947mΩ	0 to 158mΩ	0 to 1420mΩ	0 to 118mΩ
Standard Interfaces	Analogue, Ethernet (up to 800 × 16 bit/s) & USB (up to 450 × 16 bit/s)					

	G5-SOURCE 36-160-676	G5-SOURCE 36-320-338	G5-SOURCE 45-80-1690	G5-SOURCE 54-80-2028	G5-SOURCE 54-160-1014	G5-SOURCE 54-240-676
Operating Modes	Constant Voltage (0 to 100% of V_{MAX}) Constant Current (0 to 100% of I_{MAX}) Constant Power (5% to 100% of P_{MAX})					
Internal Resistance Range	0 to 473mΩ	0 to 1893mΩ	0 to 95mΩ	0 to 79mΩ	0 to 316mΩ	0 to 710mΩ
Standard Interfaces	Analogue, Ethernet (up to 800 × 16 bit/s) & USB (up to 450 × 16 bit/s)					

HIGHLIGHTED FEATURE

INTERNAL RESISTANCE RANGE

Each module is built with a user programmable internal resistance range as standard. This makes the power supplies ideal for simulating the output of energy storage devices such as battery packs, fuel cell stacks and super capacitors. The exact range varies by module.

INPUT

STANDARD FEATURES

TECHNICAL DATA	
AC Line Voltage	3 × 380VAC to 480VAC ±10%
Line Frequency	50Hz/60Hz
Mains Connection Type	3L + PE (no neutral)
Rated I_{NOM} at 3 × 380VAC Rated I_{NOM} at 3 × 400VAC Rated I_{NOM} at 3 × 415VAC Rated I_{NOM} at 3 × 440VAC Rated I_{NOM} at 3 × 460VAC Rated I_{NOM} at 3 × 480VAC	15ARMS (9kW units) | 30ARMS (18kW units) | 45ARMS (27kW units) | 60ARMS (36kW units) | 75ARMS (45kW units) | 90ARMS (54kW units) 15ARMS (9kW units) | 29ARMS (18kW units) | 43ARMS (27kW units) | 57ARMS (36kW units) | 71ARMS (45kW units) | 85ARMS (54kW units) 14ARMS (9kW units) | 28ARMS (18kW units) | 41ARMS (27kW units) | 55ARMS (36kW units) | 69ARMS (45kW units) | 82ARMS (54kW units) 13ARMS (9kW units) | 26ARMS (18kW units) | 39ARMS (27kW units) | 52ARMS (36kW units) | 65ARMS (45kW units) | 78ARMS (54kW units) 13ARMS (9kW units) | 25ARMS (18kW units) | 37ARMS (27kW units) | 50ARMS (36kW units) | 62ARMS (45kW units) | 74ARMS (54kW units) 12ARMS (9kW units) | 24ARMS (18kW units) | 36ARMS (27kW units) | 48ARMS (36kW units) | 60ARMS (45kW units) | 71ARMS (54kW units)
Inrush Current	<33ARMS (9kW-18kW units) | <66ARMS (27kW-36kW units) | <99ARMS (45kW-54kW units)
Power Factor	0.99 at P_{MAX}
THDi	≤0.03 at 90%P_{MAX}
Standby Power	32W (9kW-18kW units) | 52W (27kW-36kW units) | 71W (45kW-54kW units)
Protective Earth Conductor Current at 150Hz	According to IEC 60990: <4mA (9kW-18kW units) | ≤7.5mA (27kW-36kW units) | ≤10mA (45kW-54kW units)
Input Filter Discharge to 60V	L-PE / L-L: <10s, with option /XCD: <1s

HIGHLIGHTED FEATURE

ACTIVE POWER FACTOR CORRECTION

G5-SOURCE-HC modules have Active Power Factor Correction (PFC) circuit integrated into the input stage as standard. This enhances the overall efficiency of the modules across the output power range when compared to a unit that does not have active PFC. In practice, this means a significant lower peak current value, a decrease of RMS value of the phase current and less perturbations of other equipment running on the same grid.

The inbuilt active PFC is also ideal for operating the power supply from a generator. Generators tend to be sensitive against high current peaks, and their voltage controllers may have some stability problems with non-sinusoidal load currents. The active PFC feature forms a lowpass filter and therefore, both the repetitive current peaks and also the harmonic content is enhanced. This will help the generator system maintain a stable and reliable output.

OPTIONS

CODE	DESCRIPTION
/FILTER	Input air filter

HIGHLIGHTED OPTION

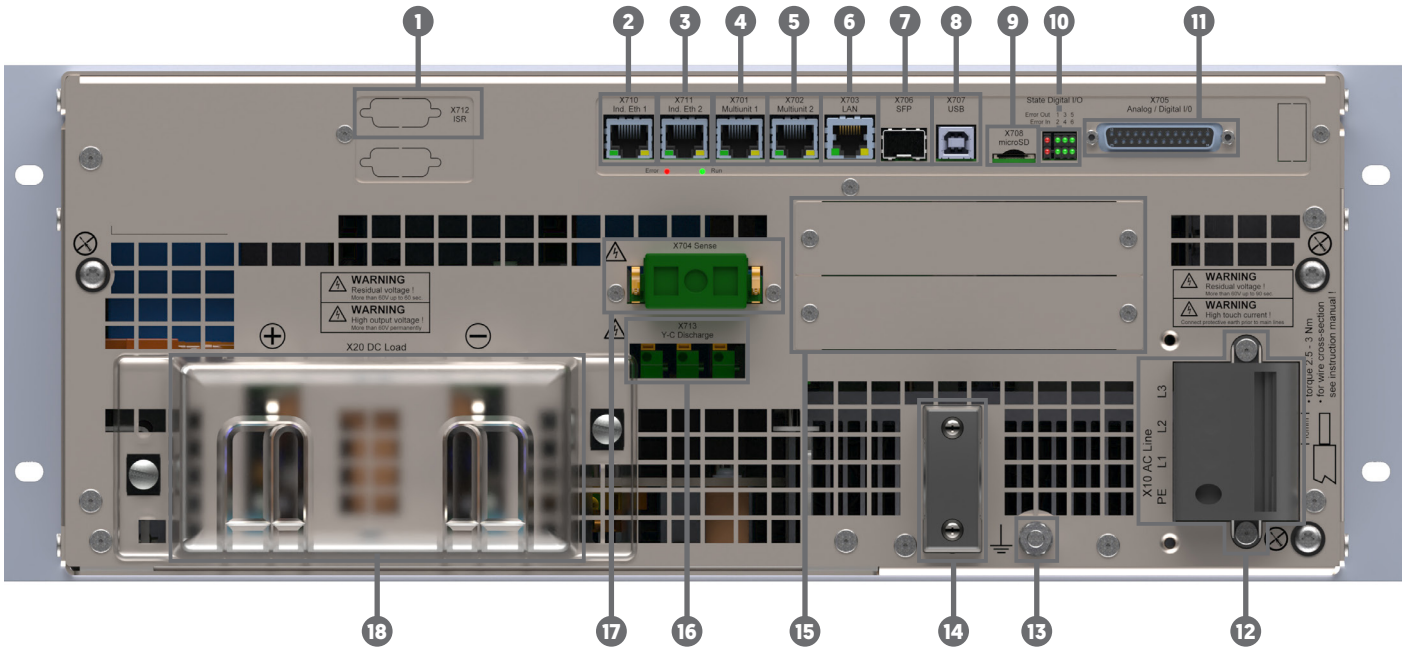
INPUT AIR FILTER (/FILTER)

The G5-SOURCE-HC modules are designed to be operated within a clean laboratory environment. If there is the possibly that the environment will be less clean, then the optional front panel frame and air filter arrangement offer some additional protection. The standard filter material is rated in class G3. This class is effective at trapping a high proportion (90%) of particles ≥10um according to EN 779.

Air filters have proven beneficial in environments where there is the risk of some metal working potentially leading to swarf contamination. Please note that the units with or without air filters must not be operated in environments where fine conductive dust is present.

INTERFACES AND CONTROL

STANDARD INTERFACES



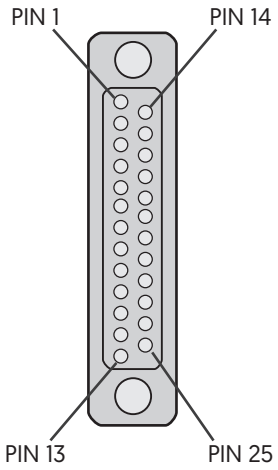
TECHNICAL DATA			
1	Optional	X712	Slot reserved for optional integrated safety relay (/ISR) interface.
2	Future Release	X710	Industrial Ethernet, e.g. EtherCAT. This interface can be easily retrofitted in the field once released.
3	Future Release	X711	Industrial Ethernet, e.g. EtherCAT. This interface can be easily retrofitted in the field once released.
4	Standard	X701	Multi-device communication interface SORTE protocol for parallel, series and matrix connection of modules.
5	Standard	X702	Multi-device communication interface SORTE protocol for parallel, series and matrix connection of modules.
6	Standard	X703	LAN interface (for external remote control).
7	Future Release	X706	Small form-factor pluggable (SFP) port which features a fibre optic card. Speeds up to 48kHz are planned via a direct connection to the G5-SOURCE-HC's controller. The SFP will also a allow a planned integration with Aurora protocol to support real-time controllers such as Typhoon and OPAL-RT. This additional functionality will be easily enabled in the field once released.
8	Standard	X707	USB interface (for external remote control).
9	Future Release	X708	Unassigned micro SD slot, with the potential of module datalogging planned in the future. Release date yet to be confirmed.
10	Standard	State Digital I/O	Status indication of digital I/O status on X705.
11	Standard	X705	Proportional 0-10VDC isolated analogue interface (detailed overleaf).
12	Standard	X10	AC line side connection (L1, L2, L3, PE).
13	Standard	-	Earthing terminal on unit chassis for additional earth connection.
14	Optional	-	Strain relief for AC cable.
15	Optional	-	Spare slots for optional interface cards (e.g. CANmp high speed 1kHz digital interface).
16	Standard	X713	Y-Cap discharge interface.
17	Standard	X704	Sense interface.
18	Standard	X20	DC terminals for connection to DUT with standard cover against accidental contact (touchproof cover for 9kW/18kW models is optionally available).

INTERFACES AND CONTROL

STANDARD ANALOGUE INTERFACE

An analogue interface is provided as standard which operates at 48kHz. The control port is configured as a Sub-D 25 female connector and is located on the rear panel. It allows output values to be set and read proportionally using a 0-10VDC analogue signal. Digital inputs and outputs enable various functions such as the interlock and output ON/OFF. A 10VDC reference is provided for analogue control. Digital functions are switched via a high/low signal. A 24VDC supply voltage is provided for these functions.

INPUT/OUTPUT DATA	
Number of Inputs/Outputs	4
Internal Resolution	16 bit
Input Accuracy	Bipolar range:±0.1%, Unipolar range: ±0.2%
Output Accuracy	±0.2%
Input Filter	2nd order low pass filter, cut off frequency: 15kHz
Temperature Coefficient	0.02% FS/°C
Sampling/Update Rate	48kS/s
Output Settling Time	10µs (typical)
Input Voltage Range	-10V to +10V, -5V to +5V, 0V to 5V, 0V to 10V (selectable)
Absolute Max Input Voltage	±30VDC
Input Impedance	1MΩ (typical)
Output Voltage Range	-10V to +10V, -5V to +5V, 0V to 5V, 0V to 10V (selectable)
Max Output Current	20mA (short circuit proof)
Output Impedance	0.5Ω (typical)
Delay (Typical)	89µs (input to power out), 42µs (power out to analogue out)



PIN	SIGNAL	I/O	DESCRIPTION
1	AGND	Supp	Analogue ground for pins 2–4, 14–16
2	AIN1	AI	Voltage setpoint input 0–10VDC
3	AIN2	AI	Current setpoint input 0–10VDC
4	AOUT1	AO	Current feedback output 0–10VDC
5	AOUT2	AO	Power feedback output 0–10VDC
6	AOUT3	AO	Analogue reference voltage (+10VDC)
7	DGND	Supp	(Connected to pin 17) 0VDC DigIn; common ground for pins 8–9, 18–20, 24, 25
8	APP_DIGIO_4	DI/O	Digital input/ouput[3] 0-2VDC /10-28VDC Default function: Clear error
9	APP_DIGIN_6	DI	Digital input[3] 0-2VDC /10-28VDC Default function: Voltage ON
10	REL1_14	RO	Relay output 1 normally open
11	REL1_13	RO	Relay output 1 common
12	REL2_14	RO	Relay output 2 normally open
13	REL2_13	RO	Relay output 2 common

PIN	SIGNAL	I/O	DESCRIPTION
14	AIN3	AI	Power limit analogue input 0–10VDC
15	AIN4	AI	Load resistance reference value input 0–10 VDC
16	AOUT4	AO	Voltage feedback output 0–10VDC
17	DGND	Supp	(connected to pin 7) Common ground to pins 8–9, 18–20, 24, 25
18	APP_DIGIO_1	DI/O	Digital input/ouput[3] 0-2VDC/10–28VDC
19	APP_DIGIO_2	DI/O	Digital input/ouput[3] 0-2VDC/10–28VDC
20	APP_DIGIO_3	DI/O	Digital input/ouput[3] 0-2VDC/10–28VDC No default function
21	REL3_14	RO	Relay output 3 normally open (warning)
22	REL3_12	RO	Relay output 3 normally closed (warning)
23	REL3_11	RO	Relay output 3 common (warning)
24	APP_DIGIO_5	DI/O	Digital input/ouput[3] 0-2VDC/10–28VDC No default function
25	+24 VDC	Supp	+24VDC I/O Aux power output 24VDC, max. 650mA

[1] Pin 5 (0 VDC) is used as the reference earth for pin 25 (24 VDC) and is connected internally to the equipotential bonding via a 1 kΩ resistor to earth.
[2] Maximum switching current: 1 A; maximum switching voltage: 24 V. [3] On request digital pins can be programmed for a specific application.

DIGITAL I/O	
Number of Digital Inputs/Outputs	6 (each can be used as input or output)
Output Voltage Supplied for Digital I/O	24VDC (-15%/+20%)
Digital Input Characteristic	IEC61131-2 Type 1
Digital Input Filter	3.2ms (10µs, 1ms and 10ms factory configurable)
Digital Output Switching Time	T_{ON}: 64-120µs, T_{OFF}: 90-170µs
Update Rate Digital Outputs	1kS/s

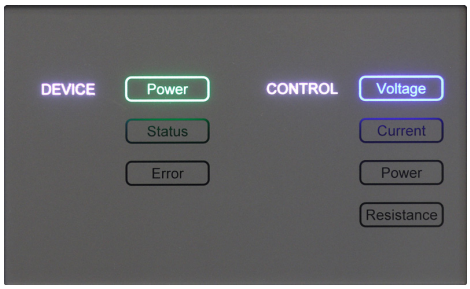
DIGITAL I/O	
Max Voltage Digital Inputs	30VDC
Sampling Rate Digital Inputs	1kS/s
Digital Output Type	High-side switch
Load Type	Ohmic, inductive, lamp load
Max Total Output Current (All Channels)	0.65A
Max Output Current Per Channel	0.625A (short circuit proof)

RELAY OUTPUTS	
Number of Relay Outputs	2 × SPST (NO), 1 × SPDT
Load Type	Ohmic, inductive, lamp load
Max Switching Voltage	30VDC
Max Switching Current	SPST: 3A, SPDT: 1A
Update Rate	48kHz

HIGHLIGHTED FEATURE

FRONT PANEL INDICATION

As standard the front panel has backlit indicators which illuminate to show which control mode the power system is operating in (CV, CC, CP, CR). When the G5-SOURCE-HC has been successfully energised, the corresponding power light illuminates green to indicate this. An illumination is also provided to visually warn users of any status (yellow) or error (red)



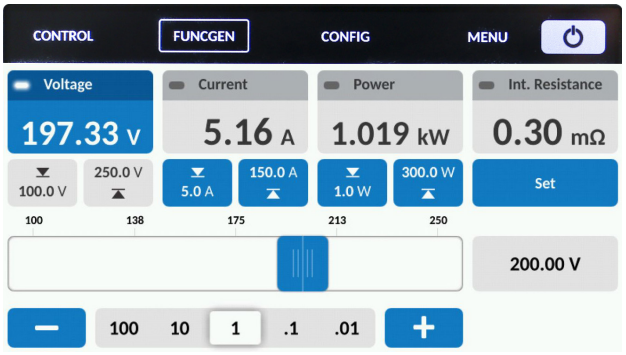
OPTIONAL INTERFACES

CODE	DESCRIPTION
/HMI	Touchscreen HMI providing front panel control and measurement.
/CANMP	Integrated CANmp interface.
/ETHERCAT	EtherCAT interface.

HIGHLIGHTED OPTIONS

TOUCHSCREEN HMI (/HMI)

The optional HMI provides a simple and intuitive way of control and measurement via a touchscreen panel. Users can directly access features such as the system's protections, warnings/errors and optional function generator without the use of a computer. A user defined passcode can be set to lock the touch screen, which prevents unauthorised access. When selected, the HMI replaces the front panel indicator.



CAN MULTI-PURPOSE INTERFACE (/CANMP)

CANmp is a high speed digital interface operating at 1kHz. The interface gives users the capability to customise the CAN protocol. Up to 50 messages are user configurable. Along with the CAN ID the data length code, byte order, start bit, data type and signal factor can be adjusted by the user. A DBC file is provided and messages can be easily configured within the standard windows software. Messages can be sent cyclically or upon receipt of a sync or syncID signal.

SOFTWARE/SOFT TOOLS

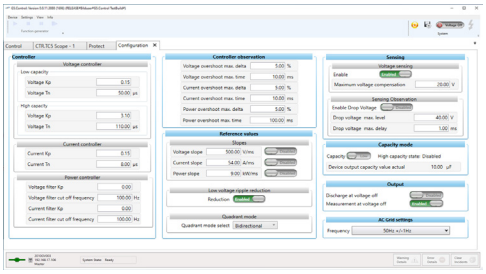
STANDARD G5.CONTROL GUI

All G5-SOURCE-HC units come with a simple and intuitive G5.Control operating GUI as standard. Live values of the power system are displayed graphically along with any warning and error messages. The software provides a variety of second level parameters, ideal for users who like to optimise their test processes. In standard user mode the operator can remotely program set values, enable voltage output as well as the ability to analyse different variables including set and actual values via the integrated scope.

The scope function can simultaneously record up to 8 system variables. Recording can be started manually or by a defined trigger event from any variable of the system. All actual and set values (currents/voltages/power/internal resistance) can be recorded. Other recordable items include system temperatures, intermediate DC circuit, low voltage auxiliary power supplies, error related values and variables from the controller section.

A password protected section is available to the advanced user and service technician. In addition to the standard functions the authorised user is able to:

- Program linear ramp functions at start up and set value steps during operation
- Configure multi-unit operation
- Program the PI controller parameters
- Program the unit's limit values
- Calibrate and adjust values as necessary
- Update the firmware



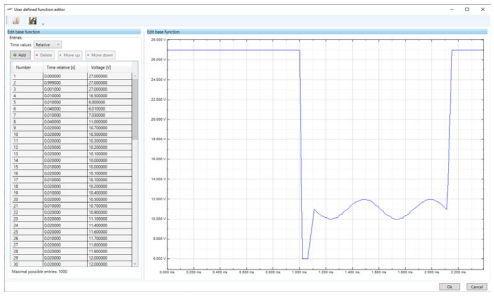
OPTIONAL SOFTWARE

CODE	DESCRIPTION
/TFE	Integrated function generating engine for time based programming
/AAP	Integrated function generating engine with application area (parametric) programming
/BATSIM	GUI simulating battery characteristics with adjustable parameters
/BATCONTROL	Energy storage and drive cycling GUI
/SASCONTROL	Solar array simulation GUI (includes AAP option)

HIGHLIGHTED OPTIONS

FUNCTION GENERATOR (/TFE & /AAP)

Complex DC waveforms can be implemented through an optional embedded function generator. The highly programmable nature of the function generator allows users to plot out exact waveforms. This is often advantageous when emulating a power device with a very specific behaviour profile. For example, when quality testing fuel cell powered equipment, the specific behaviour of a discharging fuel cell can be programmed and replicated.



As well as custom shapes, standard square, sawtooth and sine waveforms can be plotted against time. Voltage/current and voltage/power relationships can also be programmed where necessary. Parametric programming is possible when selecting option /AAP, where instead of the time axis, an input variable (V_{IN}, I_{IN} or P_{IN}) can be selected.

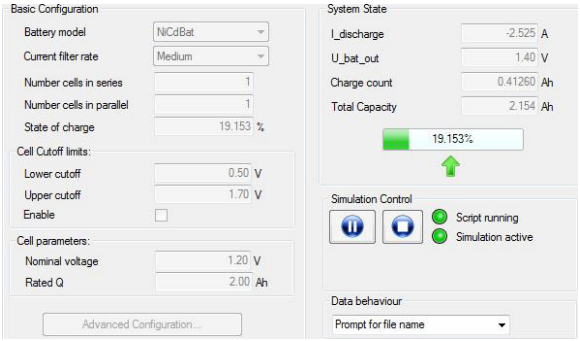
APPLICATION SPECIFIC GUIs

HIGHLIGHTED OPTIONS

BATTERY SIMULATION (/BATSIM)

BatSim is a battery emulation GUI for use with G5-SOURCE-HC power systems. The GUI allows the power supplies to simulate real world behaviour of a battery pack.

Emulating a battery pack allows specific sections of a circuit to be isolated and researched. Nearly all relevant electrical characteristics are programmable including number of cells, energy capacity, cut off limits, chemistry type and nominal voltage. The modularity of the power systems provides a convenient method to emulate different size battery stacks. Hard to replicate conditions, such as a cranking curve from a cold start can be programmed and repeated when used in conjunction with the function generator.



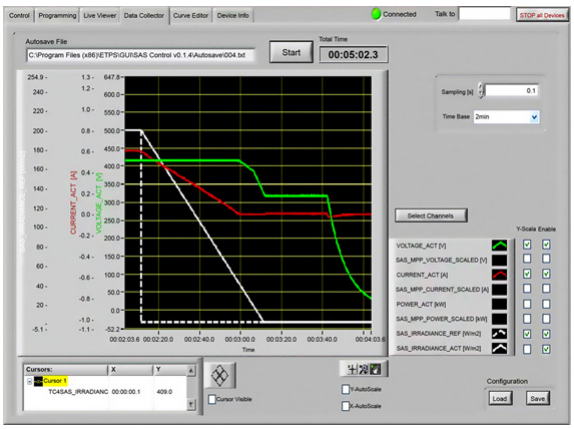
The multi-channel data logger provides live reporting and output to file (CSV) with timestamps. Previously recorded data can be imported, reviewed and compared in the analyser mode. Other features include:

- Adjustable internal resistance and discharge current
- Variation of exponential capacity and voltage levels
- Emulation of common battery chemistries
- Novel chemistries available on request
- Series/parallel configuration of cells

SOLAR ARRAY SIMULATION (/SASCONTROL)

SASControl software has all EN 50530 tests pre-installed, with minor adaptations possible for particular inverter models. The GUI allows users to edit irradiance, temperature, amplitude values or input scaling with special commands.

Previous tests have been conducted using over 400,000 individual data points, with more possible. This allows users to simulate changing conditions over the course of day.



APPLICATION SPECIFIC GUIs

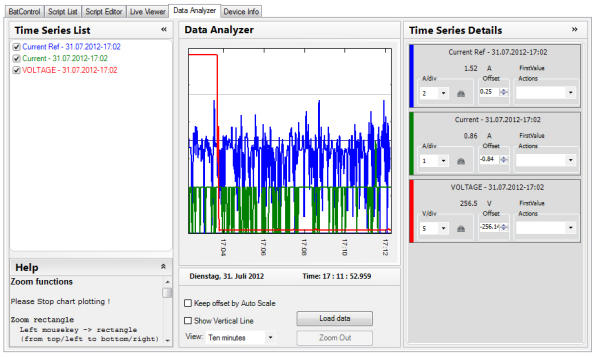
HIGHLIGHTED OPTIONS

ELECTRIC DRIVE AND BATTERY CYCLING (/BATCONTROL)

Drive cycle tests can be implemented using BatControl. The GUI's main screen provides an overview of the main test values for all BatControl operations. Live data from the connected power system is displayed, and setting/adjustment of primary values is possible.

Previous data obtained from a test track can be imported and recreated, allowing the G5-SOURCE-HC to simulate a real world driving test inside a lab environment. Battery and capacitor charge/discharge profiles can also be implemented through the GUI. An internal charge counter allows users to view live data for Wh and Ah. Energy storage orientated tests which users can program include:

- Battery charge/discharge cycles
- Automated drive cycle loading and simulation
- Fuel cell loading
- Comparative studies
- Shot and burst overload tests
- System degradation tests
- Battery lifetime tests



ISOLATION

STANDARD FEATURES

TECHNICAL DATA	
DC+/DC- Output to PE	640VDC
Input Isolation Test Voltage (Line to Case/Logic)	3100VDC (2s)
Output Isolation Test Voltage (Output to Case/Logic)	1090VDC (2s)
AC Terminals to PE	900VDC
AC to DC Terminals	640VDC
Resistance (DC+/DC- output to PE)	X713 jumper inserted: 9.5MΩ, X713 jumper removed: open

MECHANICAL

STANDARD FEATURES

TECHNICAL DATA	
AC Terminals (9kW-18kW units) AC Terminals (27kW-54kW units)	Screw terminals 6 to 25 mm^2 wires Screw terminals 6 to 35 mm^2 wires, diameter ≤8.5mm
DC Terminals	Output bars for M12 bolts (adapter for additional M12 bolt included for 80V units between 36kW-54kW)
Cooling	Direct forced air, front to back
Operating Altitude	≤2000m above sea level (slight temperature derating possible above 1000m)
Operation Temperature	-5°C to +40°C (-5°C to +30°C with optional air /FILTER or /PACOB installed)
Storage Temperature	-25°C to +70°C
Relative Humidity	0 to 95% (non condensing)
Vibration	IEC 60068-2-6 (Test Fc)
Acoustic Noise Level (1m From Front of Unit)	≤54dB (90% P_{MAX}/90% I_{MAX} at +25°C ambient)

SAFETY AND PROTECTION

STANDARD FEATURES

TECHNICAL DATA	
Over Voltage Protection	Programmable
Over Current Protection	Programmable
Over Power Protection	Programmable
Over Temperature Protection	Standard
Protection Class	1 (EN 62477-1)
Degree of Pollution	2 (EN 60664-1)
Overvoltage Category	Mains input, EN 60664-1/EN 62477-1: 3, other interfaces: 2
Safety of Machinery	EN ISO 13849-1:2015 N/A (without option /ISR), PL c (with 2 channel /ISR), PL e (with 2 channel /ISR and external safety relay)
Low Voltage Directive 2014/35/EU	EN 62477-1:2012 + A11:2014 + A1:2017 + A12:2021 EN 61010-1:2010
Electrical Equipment (Safety) Regulations 2016	BS EN 62477-1:2012+ A11:2014 + A1:2017 + A12:2021 BS EN 61010-1:2010
Directive 2014/30/EU EMC emission (industrial)	EN 61000-6-4:2007 A1:2011 / EN61000-6-4:2019 EN 61000-6-2:2005 / EN 61000-6-2:2019
Electromagnetic Compatibility Regulations 2016 EMC emission (industrial)	BS EN 61000-6-4:2007 A1:2011 /BS EN61000-6-4:2019 BS EN 61000-6-2:2005 / BS EN 61000-6-2:2019
Directive 2014/30/EU EMC industrial level A	EN 61326-1:2013
Electromagnetic Compatibility Regulations 2016 EMC industrial level A	BS EN 61326-1:2013
RoHS Directive	EN IEC 63000:2018
The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012	BS EN IEC 63000:2018
EMV-ILA 01-03b	Emission 9 to 150 kHz test stand area

OPTIONS

CODE	DESCRIPTION
/ISR	Integrated safety relay for shutdown to EN 13849-1 Cat 2/3
/RPP	Automatic voltage matching with reverse polarity protection
/PACOB	Touchproof protective cover for AC and DC terminals (9kW and 18kW units only), mandatory for tabletop use
/XCD	A safety discharge circuit which quickly removes a residual voltage hazard from the module within 1s, should the plug be accidentally removed while the G5-SOURCE-HC is energised
/SELV	60V model featuring the same technical specifications as a selected 80V unit, with additional safety features to meet SELV requirements (Separated Extra Low Voltage)

HIGHLIGHTED OPTIONS

AUTOMATIC VOLTAGE MATCHING WITH RPP (/RPP)

When researching energy storage devices, Reverse Polarity Protection (RPP) is recommended for devices without an automatic voltage matching circuit. With the G5-SOURCE-HC energised but output off, the RPP senses the voltage of the connected energy storage device. A contactor is closed after matching the voltage, to prevent large inrush currents and arcing on start up. The sense lines of the G5-SOURCE-HC are used to measure the battery voltage. A switched sense is also provided ensuring there is quiescent current draw at voltage off state.

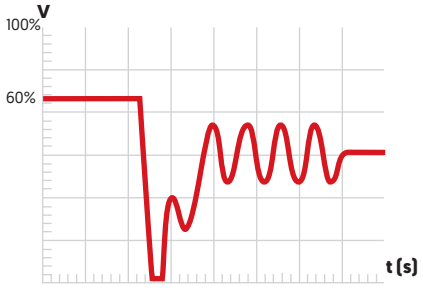
INTEGRATED SAFETY RELAY (/ISR)

For additional safety, a mechanical interlock is available for the mains input of the G5-SOURCE-HC. The integrated safety relay provides shutdown safety according to EN 13849-1 category 2/3. The ISR is connected to the external safety switch loop. If the external loop is opened, the DC-output of the power system is powered down immediately.

COMMON G5-SOURCE-HC APPLICATIONS

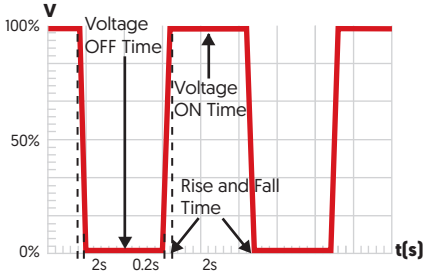
CRANKING CURVE TESTING

Electrical components within a vehicle's subsystem must be able to withstand a wide range of input voltage surges and drops during a start-up. The G5-SOURCE-HC can accurately recreate these conditions within a lab environment. This increases reproducibility and accuracy of results when compared to using real batteries. Hard to replicate conditions such as voltage cranking during a cold start can be achieved. Voltage/current and voltage/power relationships can be programmed against time where necessary.



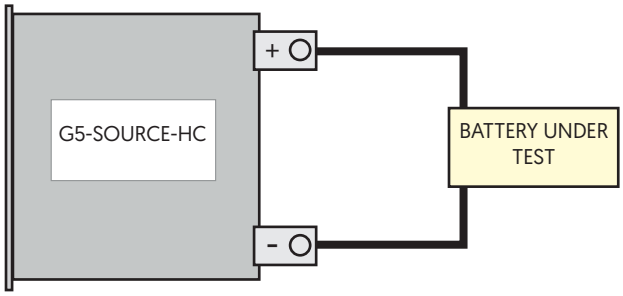
PULSED BATTERY CHARGING

Pulse charging interrupts the traditional DC charging curve with short relaxation periods. The technique is thought to improve battery discharge capacity and help facilitate longer cycle life. Some studies have shown that pulse charging is also helpful in eliminating concentration polarisation. The G5-SOURCE-HC's embedded function generator allows the PSU to deliver short burst of highly concentrated energy at user defined time intervals. The technique can also be used for powering lasers, electromagnets and plasma generation.



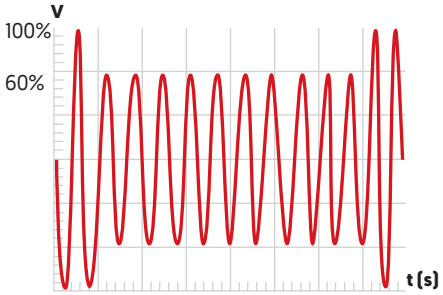
AC RIPPLE ON BATTERY LINK

A potential side effect of charger circuits that contain both AC and DC components is electrical noise. The ripple causes unwanted fluctuations in battery temperature, which results in deterioration of the battery's performance. By utilising the G5-SOURCE-HC's optional embedded function generator the user can set a current ripple at up to 10kHz to simulate this phenomenon.



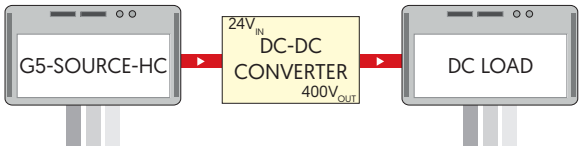
VOLTAGE DROPS & INTERRUPTS

In electronic systems sudden voltage interruptions may cause unexpected behaviour. Supply line disturbances may have several causes, including an additional switch on of large capacitive loads parallel to the supply line or a short circuit caused by loads sharing the supply. The G5-SOURCE-HC can generate many complex DC waveforms to test devices under realistic conditions to identify any potential issues.



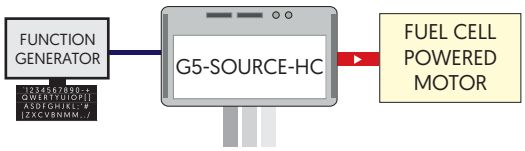
INVERTER/CONVERTER TESTING

The DC input of virtually any power conversion device can be replicated. The influence that variables, such as line voltage variation, have on performance can be isolated and tested. This allows optimum operating conditions to be characterised to improve efficiency and performance.



FUEL CELL EMULATION

The discharge behaviour of an FCEV's fuel cell is often irregular. By using the function generator, both conservative and aggressive driver profiles can be replicated. This allows the G5-SOURCE-HC to perform effective quality testing of fuel cell powered components under all likely operating conditions.



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Tel: +44 (0) 1246 452909
Sales: 0800 612 95 75
sales@etps.co.uk
www.etps.co.uk

ETPS Ltd
Unit 14, The Bridge
Beresford Way, Chesterfield
S41 9FG

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