E36731A

Battery emulator and profiler

Your Complete Battery Emulation Solution

Keysight's E36731A Battery Emulator with BV9211B PathWave BenchVue advanced battery emulation software solution provides a test environment for you to run battery tests and perform battery emulation with ease. You can perform charge, discharge of a battery, and use it to automatically create battery profiles at various test conditions, which you can then use to emulate the different states of charge (SoC) of your device under test (DUT). Additionally, the easy-to-use battery cycler lets you monitor battery aging and stability. The E36731A plus the BV9211B is a complete battery emulation solution, allowing you to test, emulate, and automate in a compact bench form factor.

KEYSIGHT

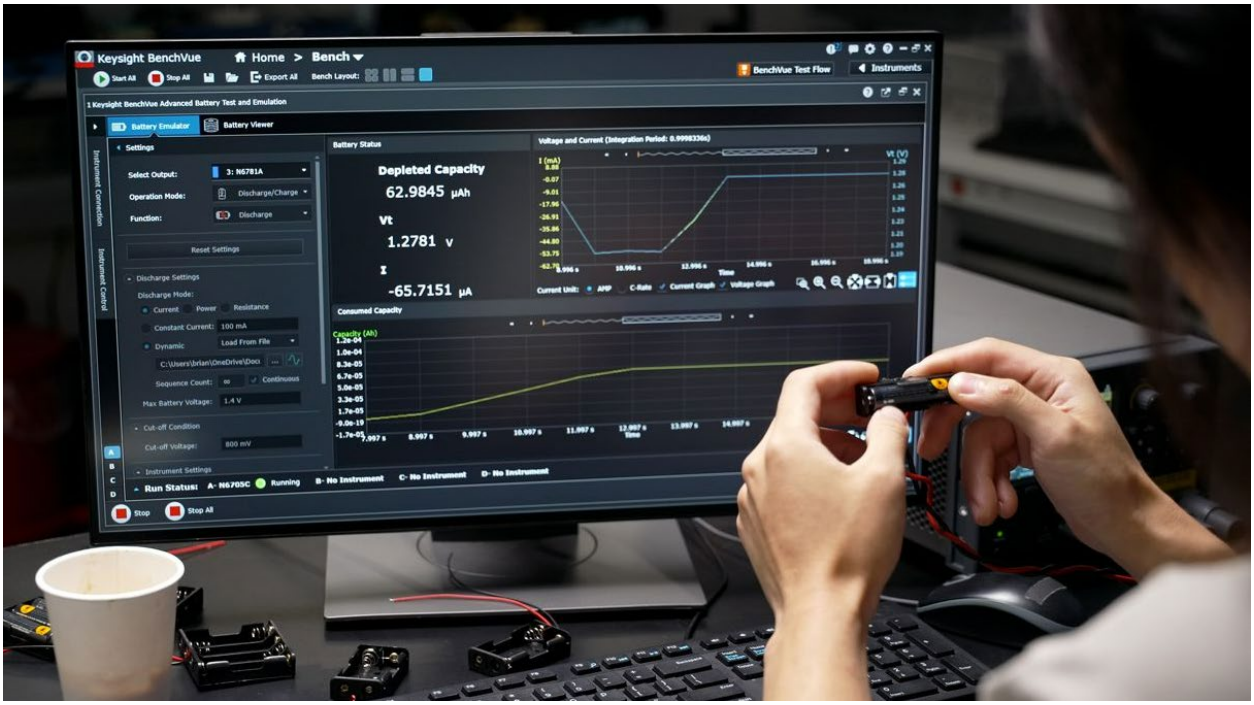
Quickly Optimize Your Device for Better Battery Life with BV9211B Advanced Battery Emulation Software

The E36731A is designed to operate with Keysight BV9211B Pathwave BenchVue Advanced Battery Emulation software. This software allows you to easily profile and generate battery models with or without temperature monitoring and perform battery emulation on the bench.

Generating a battery profile ensures you get the most accurate models for emulating your device's battery in various operating scenarios. The E36731A plus BV9211B solution creates a battery profile by discharging or charging a physical battery with either a static current condition or a previously created dynamic loading profile.

For battery emulation, you can load the software-generated profiles or import the previously created external battery models. For simplicity, you will only need to enter these four parameters to emulate a battery: capacity rating, current limit, initial SoC, and cut-off condition.

You can also create a custom sequence of charging, resting, and discharging a battery at various test conditions. The application allows up to one thousand cycle operations on the battery to determine the battery's aging effect and reliability under sequence test conditions. All of these enable you to quickly optimize your device for better battery life.



BV9211B PathWave BenchVue Advanced Battery Test and Emulation Software

The Keysight E36731A works with the BV9211B Pathwave BenchVue Advanced Battery Test and Emulation software to run battery tests, generate battery models, and perform battery emulation. The emulation function allows you to quickly change and output the desired battery operating conditions to cover various test scenarios without having to wait for an actual battery to go through discharging or charging conditions.

Key features:

- Tests and emulates batteries up to 200kW and up to 2000V (depending on the instrument models)
- Supports four modes of operation: emulation, profiler, discharge/charge, and cycler
- Creates custom battery models
- Controls up to four instruments at a time
- Includes API functions to facilitate integration into your programming environment
- Provides advanced control capabilities - capacity rating, state of charge, constant or dynamic level selection, pulse width control
- Measures voltage and current simultaneously with its built-in digitizer
- Captures voltage, current, and capacity accurately from seconds up to days
- Creates custom dynamic loading characteristics for discharging
- Imports battery models
- Exports measurement data
- Provides a graphical view of the battery model
- Provides customizable battery protection parameters

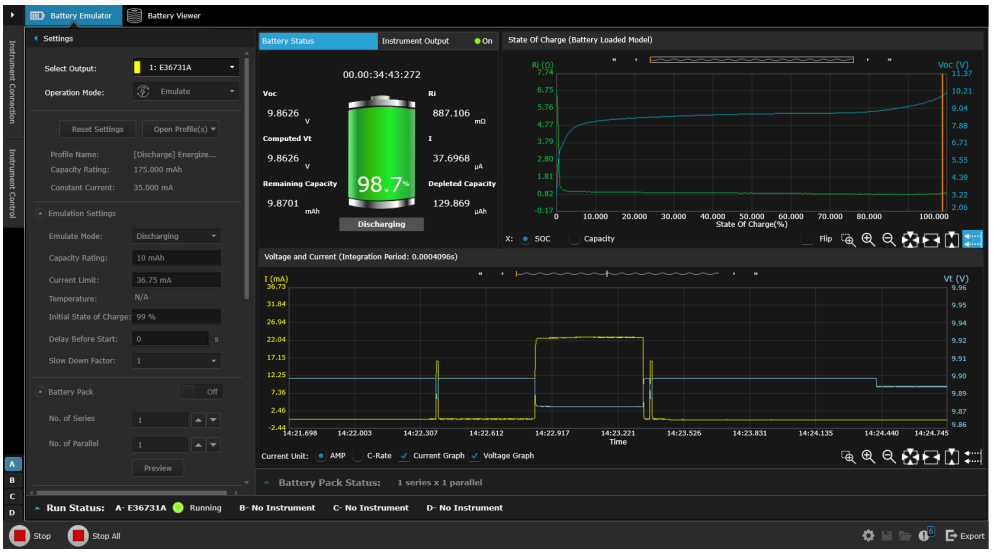


Figure 1. BV9210B PathWave BenchVue Advanced Battery Test and Emulation Software

Profiler - create battery models tailored around device behavior

A battery profiler is a must-have tool if you are working with different batteries or if you need to create your own custom battery model library. A battery profiler ensures you get the most accurate models for battery life predictions tailored to your devices and working scenarios.

The BV9211B software enables you to create custom battery models when charging or discharging a physical battery. You can efficiently perform battery discharging with a static or dynamic current loading profile, constant resistance, or power. Furthermore, the BV9210B can generate a battery model profile of up to 200 points. Each point includes the open circuit voltage (Voc), series resistance (Ri), and state of charge (SoC). The software will automatically build up the battery model until it meets the stopping condition. While discharging or charging a battery, the software continuously captures parameters like Voc, Vt, Ri, Current, Time, Capacity, SoC, and Temperature in real time. The profiler also can export all graphed data while the test is running for further analysis.

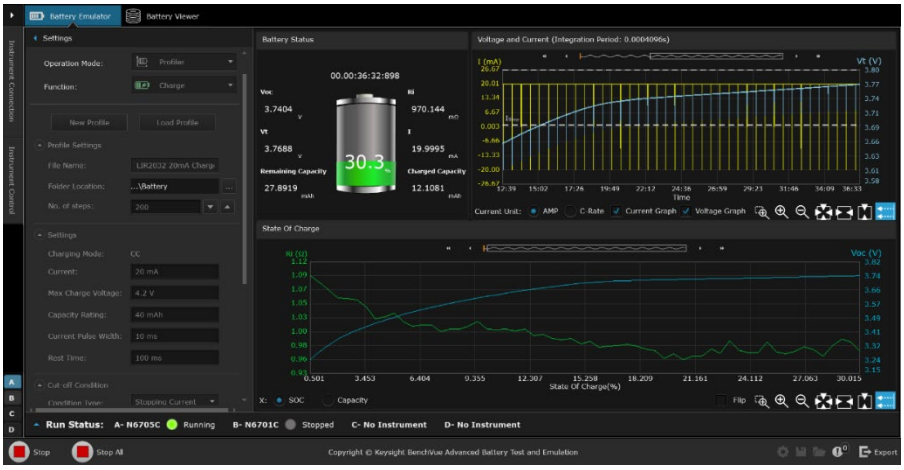


Figure 2. Creating a battery model with static profiler function.

Figure 3. Creating a battery model with dynamic profiler function.

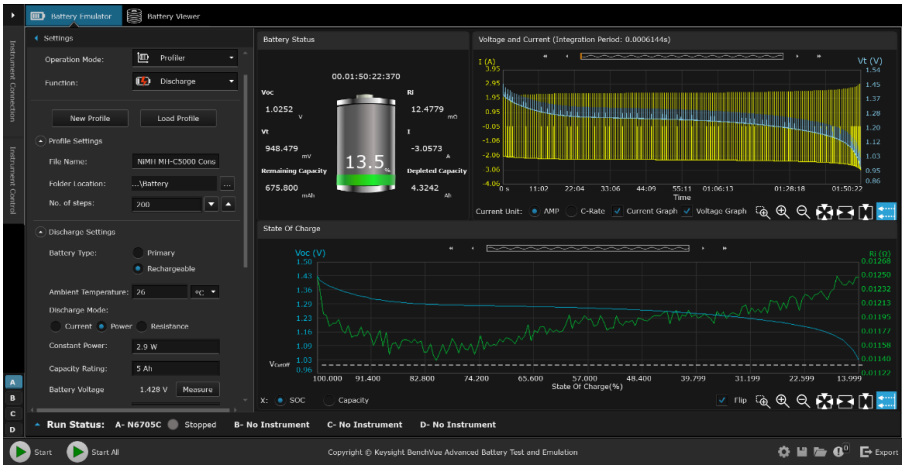


Figure 4. Creating a battery profiler with ambient temperature and constant power discharge features.

Emulation – battery emulation reduces test time

Battery emulation is a critical process, allowing you to quickly understand your device's current drain in real-life scenarios at different charge levels. Using a battery emulator instead of an actual battery has many advantages. A battery emulator helps create a safer test environment and allows the validation of the device's various operational modes.

To emulate battery characteristics, start by loading a battery model into BV9211B Advanced Battery Test and Emulation software. The software algorithm will follow the battery model in real-time and emulate the battery behavior. The software supports two types of battery models - profiles generated by the software or external battery models with Voc, SoC, and Ri parameters in a CSV file. For simplicity, you will only need to enter four parameters to emulate a battery – capacity rating, current limit, initial SoC, and a cut-off condition. While emulating a battery, the software simultaneously measures voltage and current continuously and saves the measurement results. The software allows you to instantly change the charge of the battery. Also, you can load multiple battery models created at different temperatures.

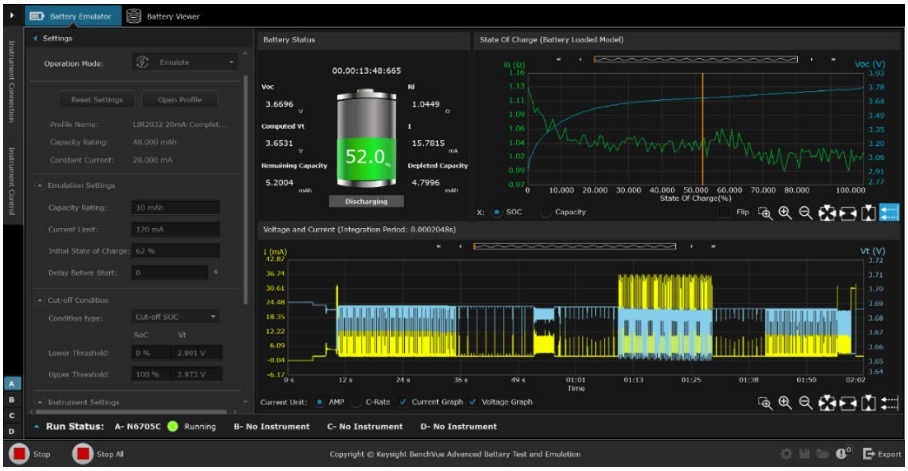


Figure 5. BV9210B Emulating Lithium battery powering a low-power device.

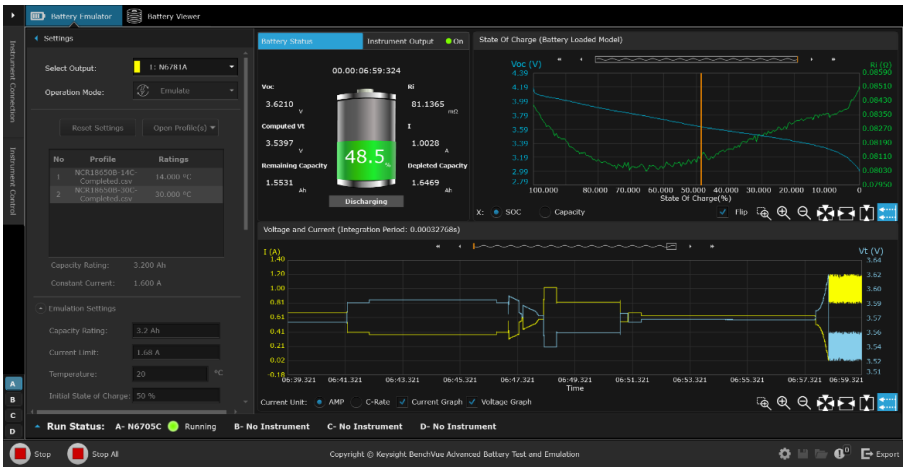


Figure 6. BV9210B Emulating multiple battery models at different temperatures.

Cycler – life cycling battery characteristics

The cycling function lets you create a custom sequence of charging, resting, and discharging a battery at various test conditions. The software enables you to make up to one thousand cycle operations on the battery to determine the effect of battery aging and the battery's reliability under sequenced test conditions. While performing these sequences, the software monitors the battery's health and records test data parameters of capacity, terminal voltage, current, and time. The cut-off condition features allow you to define a stop condition where cycling will automatically stop once the capacity loss percentage is reached.

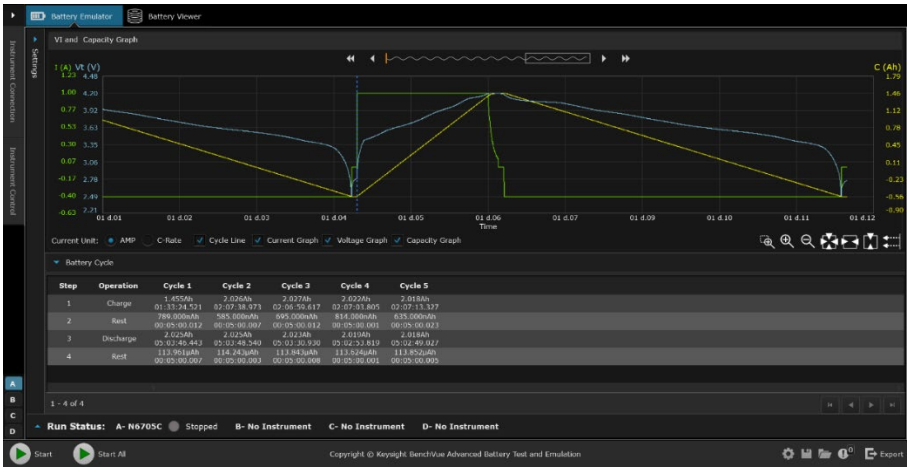


Figure 7. BV9210B Cycle testing an 18650 battery.

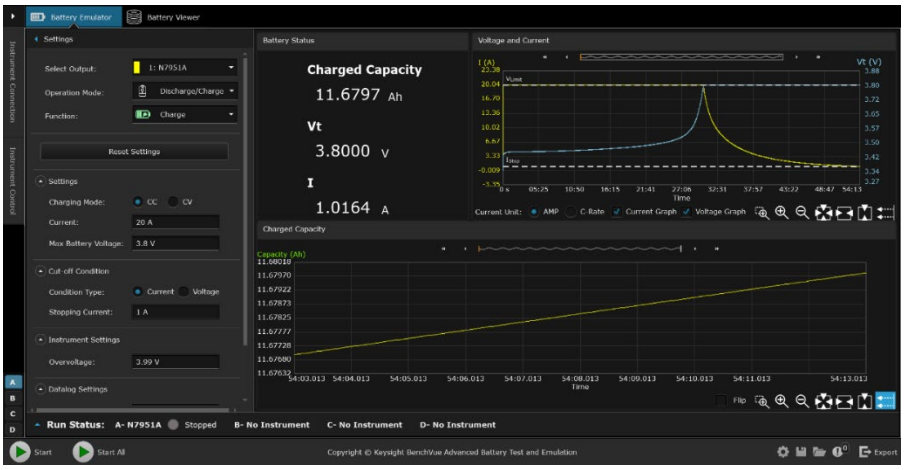


Figure 8. BV9210B Performing a battery charging on an iron phosphate battery

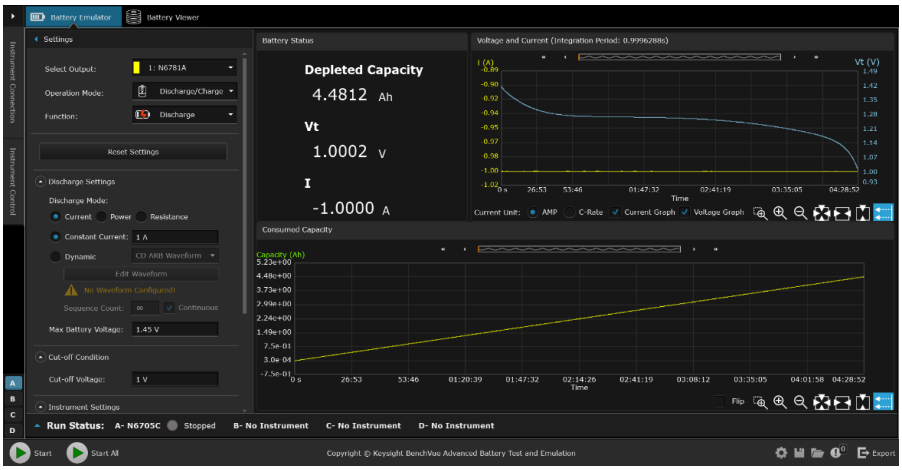


Figure 9. BV9210B enables you to choose various discharge mode options (constant current, power, resistance, and dynamic current discharge)

Importing battery model characteristics

The BV9210B software provides an effortless way to import battery models created outside the BV9210B test environment. You can import a CSV file consisting of the following battery parameters: state of charge, open circuit voltage, and series resistance parameters

State of Charge(%)	Open Circuit Voltage(V)	Internal Resistance(ohm)
100.00	9.609423	7.544065
99.50	8.828673	3.889564
99.00	8.645126	3.791465
98.50	8.516480	3.767940
98.00	8.411436	3.780916
97.50	8.320710	3.804418
97.00	8.240466	3.840828
96.50	8.167970	3.886445
96.00	8.102751	3.927822
95.50	8.043658	3.971063
95.00	7.990255	4.014665
94.50	7.942882	4.057762
94.00	7.899871	4.098643

Figure 10. BV9210B Importing a CSV file battery model

Free Trial and Licensing

The BV9210B software is available for download with a 7-day free trial. Connect to your instrument for free with the built-in 7-day trial license. After the seven-day trial period, an extension trial is available for an additional 30 days once you enter your credentials. To purchase a license, choose the BV9211B single power supply option or the BV9210B multiple power supply option. The purchased license resides on the PC or network, depending on the license type.

Download the software at: www.keysight.com/find/BV9210

Two-Quadrant Architecture

Power supply function

The power supply function has a power output of up to 200 W, a current output of 20 A, and a voltage output of 30 V. It also has autoranging technology, which provides the highest current available at all output voltages, allowing you to meet the needs of various bench applications.

It has never been easier to create data logs for measurements taken over a specific period. The power supply has a large color display, data logging capabilities, and on-board memory. You can now log voltage and current measurements at the same time, separated by a programmable sample period, and save or export the graph in PNG/BMP format. You can even export the log file as time-stamped data in a .CSV format for reports and documentation.

Using the LIST mode, you can easily simulate common power problems or normal operation by performing complex sequences of output changes with fast and precise timing that are synchronized with internal or external signals.

The variable voltage slew rate allows for easy control of the rate at which the output slews from one voltage to another. All of this is accessible and programmable via the front panel of your power supply or computer for maximum productivity and efficiency.

Electronic load function

With a power of up to 250 W, the electronic load function provides superior performance. It can sink up to 40 A of current while supporting voltages of up to 60 V.

The electronic load function, like the power supply function, allows you to continuously log voltage and current to a data file. You can either save the data file internally or export it as a CSV file to a USB drive.

A dynamic load profile can be used to test the transient response of your power source. Like an oscilloscope, the built-in scope digitizes voltage and current and displays the results on the large built-in display. External current shunts or current probes are no longer required thanks to the built-in scope function. This feature significantly reduces measurement setup complexity while still providing accurate and fully specified measurements.

Intuitive and easy-to-use front panel interface and flexible IO connectivity

The 4.3-inch LCD color display shows the voltage and current of all channels in different view modes. The knobs, user-interface windows, and binding posts are color-coded to keep the setup straightforward and help you to avoid setup and connection errors. It also has two rotary encoder knobs for voltage and current for precise adjustment, plus an instrument keypad that allows quick adjustments and configuration in less time. The E36731A has rear output terminals for easy wiring, which is ideal for both bench and system setup.

The E36731A ships standard with LAN and USB. GPIB is available as an option.

Figure 11. The front and rear view of the E36731A

Specification

Accuracy (at 23 °C ± 5 °C)		E36731A
DC power supply output rating		
Voltage		0 to 30 V
Current		0 to 20 A
Power		200 W
Programming accuracy		
Voltage		0.025% + 1.5 mV
Current		0.035% + 1.5 mA
Readback accuracy		
Voltage		0.025% + 1.5 mV
Current [1]	Low, 0.1 A	0.035% + 10 µA
	Mid, 2 A	0.03% + 300 µA
	High, 20 A	0.05% + 250 µA
Load and Line Regulation, Voltage		0.01% + 2 mV
Load and Line Regulation, Current		0.01% + 250 µA
Ripple and noise, Vpp (20 Hz to 20 MHz)		< 7 mVpp
Ripple and noise, Vrms (20 Hz to 10 MHz)		< 600 µVrms
Load transient recovery time (Time to recover within the settling band following a load change from 50% to 100%; and from 100% to 50% of full load)		
Voltage settling band		15 mV
Time		< 50 µs
Electronic load input rating		
Voltage		0 to 60 V
Current		0 to 40 A
Power		250 W
Programming accuracy		
Constant current mode	Low, 4 A	0.05% + 820 µA
	High, 40 A	0.05% + 7.2 mA
Constant voltage mode	Low, 15 V	0.03% + 4.2 mV
	High, 60 V	0.03% + 15 mV
Constant resistance mode [2]	Low, 0.08 Ω to 30 Ω	0.1% + 160 mS
	Mid, 10 Ω to 1.25 kΩ	0.1% + 16 mS
	High, 100 Ω to 4 kΩ	0.1% + 1.8 mS
Constant power mode	Low, 0.02 W to 5 W	0.08% + 18 mW
	Mid, 0.15 W to 25 W	0.08% + 150 mW
	High, 1.5 W to 250 W	0.08% + 1.5 W
Readback accuracy		
Current	Low, 4 A	0.05% + 820 µA
	High, 40 A	0.05% + 7.2 mA
Voltage	Low, 15 V	0.03% + 4.2 mV
	High, 60 V	0.03% + 15 mV
Power	Low, 0.02 W to 5 W	0.08% + 18 mW
	Mid, 0.15 W to 25 W	0.08% + 150 mW
	High, 1.5 W to 250 W	0.08% + 1.2 W

1. The current measurement range is set by default to 'High' or 'Mid.' The 'Low' current measurement range can be manually enabled or disabled when required.
2. Does not apply to current setting < 0.05% of full-scale current, minimum voltage = 0.5 V.

Typical characteristics

		E36731A	
DC power supply characteristics			
Programming resolution		**Front panel**	**Remote**
Voltage		1 mV	650 µV
Current		1 mA	450 µA
Readback resolution		**Front panel**	**Remote**
Voltage		1 mV	500 µV
Current [1]	Low, 0.1 A	1 µA	1 µA
	Mid, 2 A	1 mA	100 µA
	High, 20 A	1 mA	300 µA
Programmable output resistance			
Range		-50 mΩ to 1 kΩ	
Accuracy			
Programming temperature coefficient per °C (% of output + offset)			
Voltage		0.01% + 0.6 mV	
Current		0.01% + 0.2 mA	
Readback temperature coefficient per °C (% of output + offset)			
Voltage		0.01% + 0.04 mV	
Current		0.01% + 0.2mA	
Ripple and noise, normal mode current (20 Hz to 20 MHz)		< 1 mArms	
Remote sense (maximum voltage in load lead)		0.7 V	
Over voltage protection (OVP) programming accuracy		0.2% + 0.4 V	
Over voltage protection (OVP) activation time[2]		< 5 ms	
Over current protection (OCP) activation time[2]		< 5 ms	
Up/down programming settling time to within 1% of the total excursion			
Up full load		50 ms	
Up no load		50 ms	
Down full load		30 ms	
Down no load		100 ms	
Command processing time		< 10 ms	

1. The current measurement range is set by default to 'High' or 'Mid.' The 'Low' current measurement range can be manually enabled or disabled when required.

Typical characteristics (continued)

Electronic load characteristics		
Typical minimum operating voltage at full-scale current and for full dynamic		
Current	Low, 4 A	0.15 V
	High, 40 A	1.5 V
Programming resolution		
Constant current mode	Low, 4 A	45 µA
	High, 40 A	450 µA
Constant voltage mode	Low, 15 V	170 µV
	High, 60 V	1.7 mV
Constant resistance mode[1]	Low, 0.08 Ω to 30 Ω	450 µS
	Mid, 10 Ω to 1.25 kΩ	450 µS
	High, 100 Ω to 4 kΩ	45 µS
Constant power mode	Low, 0.02 W to 5 W	675 µW
	Mid, 0.15 W to 25 W	6.75 mW
	High, 1.5 W to 250 W	67.5 mW
Readback resolution		
Current	Low, 4 A	70 µA
	High, 40 A	700 µA
Voltage	Low, 15 V	270 µV
	High, 60 V	2.7 mV
Temperature coefficients - programming / readback		
Constant current mode	Low, 4 A	0.009%/°C + 16 µA/°C
	High, 40 A	0.008%/°C + 200 µA/°C
Constant voltage mode	Low, 15 V	0.006%/°C + 110 µV/°C
	High, 60 V	0.006%/°C + 600 µV/°C
Constant resistance mode[1]	Low, 0.08 Ω to 30 Ω	0.01%/°C + 3 mS/°C
	Mid, 10 Ω to 1.25 kΩ	0.01%/°C + 250 µS/°C
	High, 100 Ω to 4 kΩ	0.01%/°C + 25 µS/°C
Constant power mode	Low, 0.02 W to 5 W	0.015%/°C + 1 mW/°C
	Mid, 0.15 W to 25 W	0.015%/°C + 3 mW/°C
	High, 1.5 W to 250 W	0.015%/°C + 30 mW/°C
Ripple and noise, Vrms (20 Hz to 10 MHz)		< 10 mVrms
Ripple and noise, normal mode current (20 Hz to 20 MHz)		< 6 mArms
Measurement Small Signal Bandwidth (-3 dB typical)		30 kHz
Measurement Small Signal Bandwidth (-1 dB typical)		17.5 kHz

Typical characteristics (continued)

Programmable short / open		
Programmable short		37.5 mΩ (4 A / 40 A)
Input off impedance		824 kΩ
Electronic Load Characteristics		
Protection		
Fixed OCP	Low, 4 A	4.35 A ± 25 mA
	High, 40 A	42 A ± 250 mA
Programming OCP	Low, 4.08 A	0.2% + 50 mA
	High, 40.8 A	0.2% + 80 mA
OVP	Low, 15 V	16.5 V +/- 85 mV
	High, 60 V	165 V +/- 600 mV
OPP	Low, 0.02 W to 5 W	5.5 W
	Mid, 0.15 W to 25 W	27.5 W
	High, 1.5 W to 250 W	275 W
Protection activation time		
INH input		< 5 µs
Fault on coupled output		< 10 µs
Minimum programmable operating point		
Constant current mode	Low, 4 A	1 mA
	High, 40 A	10 mA
Constant voltage mode	Low, 15 V	5 mV
	High, 60 V	20 mV
Constant resistance mode[1]	Low, 0.08 Ω to 30 Ω	0.08 Ω
	Mid, 10 Ω to 1.25 kΩ	10 Ω
	High, 100 Ω to 4 kΩ	100 Ω
Constant power mode	Low, 0.02 W to 5 W	0.02 W
	Mid, 0.15 W to 25 W	0.15 W
	High, 1.5 W to 250 W	1.5 W
Maximum programmable power operating point		
Constant power mode	Low, 0.02 W to 5 W	5.1 W
	Mid, 0.15 W to 25 W	25.5 W
	High, 1.5 W to 250 W	255 W
Maximum slew rates (changes over time from 10% to 90% or 90% to 10%		
Constant current mode	Low, 4 A	200 kA/s
	High, 40 A	3.7 MA/s
Constant voltage mode	Low, 15 V	79 kV/s
	High, 60 V	310 kV/s
Mainframe oscilloscope measurement accuracy		
Constant current mode	Low, 4 A	0.04% + 3 mA
	High, 40 A	0.04% + 10 mA
Constant voltage mode	Low, 15 V	0.02% + 15 mV
	High, 60 V	0.02% + 40 mV

Typical characteristics (continued)

Environmental conditions	
Operating environment	Indoor use, installation category II (for AC input), pollution degree 2
Operating temperature range	0 °C to 40 °C
Storage temperature	–20 to 70 °C
Relative humidity	Operating Condition: Up to 80% RH at temperature up to 40 °C (non-condensing) Storage Condition: Up to 90% RH at temperature up to 60 °C (non-condensing)
Altitude	Up to 2000 meters
Electromagnetic compatibility	Compliant with EMC Directive (2014/30/EU) IEC 61326-1:2012/EN 61326-1:2013 Group 1 Class A Canada: ICES-001:2004 Australia/New Zealand: AS/NZS South Korea KC mark
Safety	UL 61010-1 3rd edition, CAN/CSA-C22.2 No. 61010-1-12, IEC 61010-1:2010 3rd edition
Acoustic noise declaration	Sound pressure Lp <65 dB(A) at operator position, Lp <70 dB(A) at bystander position Sound power, Lw <70 dB(A)
AC input	100 VAC to 240 VAC (±10%), 50/60Hz
Interface capabilities	
GPIB	SCPI-1999, IEEE 488.2 compliant interface
LXI compliance	Class C
USB 2.0	Requires Keysight IO Library version 17.2.208 and up
10/100 LAN	Requires Keysight IO Library version 17.2.208 and up
Digital control characteristics	
Maximum voltage ratings	+16.5 VDC/ -5 VDC between pins (pin 4 internally connected to chassis ground)
Pins 1 and 2 as fault output	Maximum low-level output voltage = 0.5 V @ 4 mA Maximum low-level sink current = 4 mA Typical high-level leakage current = 1 mA @ 16.5 VDC
Pins 1 - 3 as digital/trigger outputs (pin 4 = common)	Maximum low-level sink current = 100 mA Typical high-level leakage current = 0.8 mA @ 16.5 VDC
Pins 1 - 3 as digital/trigger inputs and pin 3 as inhibit input (pin 4 = common)	Maximum low-level input voltage = 0.8 V Maximum high-level input voltage = 2 V Typical low-level leakage current = 2 mA @ 0 V (internal 2.2k pull-up) Typical high-level leakage current = 0.12 mA @ 16.5 VDC
Remote sense capabilities	
Inputs can maintain specifications with up to a 5-volt drop per load lead. The load lead drop reduces the maximum available voltage at the load.	
Weight and dimensions	
Model	E36731A
Weight, kg	8.3
Overall dimension, mm (H x W x D)	144.85 x 215.90 x 489.06
Net dimension (without feet, strap handle and GPIB module), mm (H x W x D)	132.51 x 212.80 x 408.24

Definitions

Specification (spec)

The specification refers to the warranted performance of a calibrated instrument stored for a minimum of two hours within the operating temperature range of 0 to 55 ºC and after a one-hour warm-up period. Measurement and calibration uncertainties comply with ISO-17025 methods. Data published in this document are specifications as indicated.

Typical (typ)

The characteristic performance that 80% or more manufactured instruments will meet. The warranty for this is not available and does not include measurement or calibration uncertainty and is valid only at approximately 23 ºC (room temperature).

Nominal (nom)

Nominal represents the mean or average characteristic performance, or the value of an attribute determined by design, such as a connector type, physical dimension, or operating speed. The warranty for this data is unavailable, and the measurement is at approximately 23 ºC (room temperature).

Measured (meas)

Measured is an attribute taken during product development to communicate expected performance. The warranty for this data is unavailable, and the measurement is at approximately 23 ºC (room temperature).

Ordering Information

Kesight E36731A

Model	Description
E36731A	Battery Emulator and Profiler
E36731ABV	E36371A Battery Emulator and Profiler with BV9211B Software (12-month Transportable License)
BV9210B	PathWave BenchVue Advanced Battery Test And Emulation Software for Four Instrument
BV9211B	PathWave BenchVue Advanced Battery Test And Emulation Software for a Single Instrument

How to order a license

Step 1 **Determine the software model**	Step 2 **Choose license term**	Step 3 **Select license type**
Choose the right software model to automate all the connected power supplies. • BV9211B: Allows only one instrument connection at a time. • BV9210B: Allows up to four instrument connections at a time.	• Subscription	• Node-locked • Transportable • USB portable • Floating – single site

Step 4 **Select duration**	Step 5 **Select USB**	Step 6 **Select delivery method**
• 6 months • 12 months • 24 months • 36 months	• Only for "USB portable"	• Paper certificate • eMail and paper certificate • eMail certificate

Standard shipped accessories

Description
AC power cord (based on destination country)
Certificate of calibration
One detachable front output connector
One rear output connector
One rear remote sense connector
One digital IO connector

Options

Model	Description
SEC	NISPOM and file security
UK6	Commercial calibration with test result data

Keysight GPIB module and rackmount kits

Model	Description
EL34GPBU	GPIB user-installable interface module
1CM104A	Rack mount flange kit with two flange brackets
1CM105A	Rack mount flange kit without handles and two flange brackets
1CM116A	Rack mount flange kit with one flange bracket, one half-module bracket
1CN107A	Handle kit with two front handles
1CP108A	Rack mount flange and handle kit with two brackets and front handles