## 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.





### 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

Select Output:	1: E36731A -	00.00:34:43:272 <sup>RI (0)</sup>	
Operation Mode:		Voc Ri 6.75	
		9.8626 887.106 5.76	
		V mΩ 4.77 Computed Vt I 2,79	
Capacity Rating:	175.000 mAh	9.8626 v 37.6968 <sub>µA</sub> 2.80	
		Remaining Capacity 98.7% Depleted Capacity	
		9.8701 129.869 ukh 0.82 0.17	32
		0 10.000 20.000 30.000 40.00	
		X: O SOC Capadity	ा । । 💷 🕫 🕀 🖯 🔀 🗖
	10 mAh	Voltage and Current (Integration Period: 0.0004095s)	
	36.75 mA	1 (mA) • • • • • • • • • • • • • • • • • • •	• • • Vt
	1e: 99 %	31.84	
		26.94	
		22.04	
		17.13	
		7.36	
		2,46	9
		<sup>-2,44</sup> 14:21.698 14:22.003 14:22.307 14:22.612 14:22.917 14:23.526 Time	14:23.831 14:24.135 14:24.440 14:24.745
		Current Unit:  O AMP C-Rate 🗸 Current Graph 🗸 Voltage Graph	ि 🔍 🖓 🔁 🚺
		<ul> <li>Battery Pack Status: 1 series x 1 parallel</li> </ul>	
		Dattery Pack Status. A series X & paranet	

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.

Settings		Battery Status	Voltage and Current (Integration Period: 0.0004096s)
			1 (mA) • • • • • • • • • • • • • • • • • • •
		00.00:36:32:898 Vox: Ki 3.7404 970.144	
		3,7404 970,144 n	
		3.7688 19.9995	-4.00 A
		Remaining Capacity 30.3 Charged Capa	city -20.00
	\Battery	27.8919 12.1081	-26.67 12:39 15:02 17:26 19:49 22:12 24:36 26:59 29:23 31:46 34:09 36:33 AF
			Current Unit: • AMP C.Rate V Current Graph Voltage Graph 🖓 e 🔍 🤅 🕰
		0.93 0.501 3.453 6.404	9.355 12.307 15.258 18.209 21.161 24.112 27.063 30.015 State Of Charge(%)
Condition Type:	Stopping Current •	X: 💿 SOC 🔅 Capacity	FID TA Q Q 🔂 🔂
Dun Statue: A-	N6705C O Running B-I	N6701C Stopped C- No Instrument D-	No Instrument

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



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



Battery Emulator     Settings	Battery Viewer	Battery Status	Voltage and Current (Integration Period: 0.0006144s)
Operation Mode:	🛅 Profiler 🔹 ^		
	Discharge •	00.01:50:22:370 Voc RI	1.09 1.09 1.09 1.09
New Profile	Load Profile	1.0252 v 12.4779 mo	0.05 L.27 L.27
Profile Settings     File Name:	NIMH MII-C5000 Cons	948.479 mv 13.5	-1.05 -2.05
	\Battery	Remaining Capacity 675.800 math	4.06 0 s 11:02 22:04 33:06 44:09 55:11 01:06:13 01:28:18 01:50:22
No. of steps:	200 💌 🔺	m4h 4h	Time Current Unit: • AMP C-Rate 🗹 Current Graph 🗹 Voltage Graph  🕀 🕀 🖓 🌄 🚺
		State Of Charge	
	Primary     Rechargeable		
Ambient Temperature: Discharge Mode:	26 °C *		
	2.9 W		
	5 Ah		4,200 65,600 57,000 48,400 39,799 31,199 22,599 13,599
Battery Voltage	1.428 V Measure	X: • SOC Capacity	State Or Charge(%)
• Run Status: A-I	16705C Stopped B- M	io Instrument C- No Instrument D- No Instr	ument
Start Start All		Copyright ⊕ Keysight BenchVue Advance	ced Battery Test and Emulation

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 cutoff 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.



Settings	Battery Status Instrument Output  On State Of Charge (Battery Loaded Model)	
Select Output: 1: N6781A •	00.00:06:59:324 Vicc (V) • • • • • • • • • • • • • • • • • • •	
Operation Mode: Cmulate *	Vic Ni 4,19 3,6210 v 81,1365 3,79 3,79	
	Computed V: I 3.59 3.5397 1.0028 3.39	
No         Profile         Ratings           1         NCR18650B-14C- Completed.csv         14.000 °C	Remaining Capacity 250 1.553 1.6469 2.09	
	4 100.000 80.000 70.000 60.000 30.000 20.000 10.000 State of Churge(%) X: ● SOC Capacity ☑ No tag Q Q X:	
	Voltage and Current (Integration Period: 0.00032768s)	
	1(0) 1.40 1.20	Vt 3
		3
		3 
	0.02 0.12 0.59,59,521 06.41.321 06.43.321 06.45.322 06.47,321 06.49,321 06.51.321 06.55.321 06.55.321 06.57,321 06.57	3 3
Initial State of Charge: 50 %	06:99.221 08:41.321 08:45.221 08:45.221 08:45.221 08:45.221 08:55	
A Run Status: A- N6705C O Running B-		

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.

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1 (A) Vt 1.23	(V)											
1.00												
							1					
-0.17												
					01 d.04	01 d.05 h 🗹 Capacity Grapi	01 d.06 Time				01 d.11	
	2.21 01 d.01 MR: • AMP						Time				्र <b>स्</b> स्	
-0.63 <sup>2</sup> Current U	2.21 01 d.01 MR: • AMP	C-Rote 🗹	Cycle Line 🗹 Cycle 2	Current Graph	Voltage Grap	h 🕑 Capacity Grapi Cycle 5	Time					
-0.63 <sup>2</sup> Current U • Batter	2.21 01 d.01 Init: AMP	C-Rate	Cycle Line Cycle 2 2.026Ab 02:07:38.973	Current Graph Cycle 3 2.027Ah 02:06-59.617	Voltage Grap Cycle 4 2.022Ah 02:07:03.805	Capacity Grapi	Time					
-0.63 <sup>2</sup> Current U Batter Step	2.21 01 d.01 Init: • AMP ry Cycle Operation	C-Rate Cycle 1 1.455/h	Cycle Line Cycle 2 2.026Ms	Current Graph Cycle 3 2.027Ah	Voltage Grap	h Capacity Grapi Cycle 5 2.018Ah	Time					
-0.63 <sup>2</sup> Current U * Batter Step 1	2.21 01 d.01 Init: AMP ry Cycle Operation Charge	C-Rate Cycle 1 1.455/h 01:33:24.521 759.00m/h	Cycle Line Cycle 2 2.026Ah 02:07:38.973 585.000n/h	Current Graph Cycle 3 2.037Ah 02:06:59.617 595.000Ah	<ul> <li>Voltage Grap</li> <li>Cycle 4</li> <li>2.022/hi</li> <li>02:07:03.805</li> <li>814.000n/hi</li> </ul>	h Capecity Graph Cycle 5 2.018Ah 02:07:13.327 635.000Ah 06:05:00.023 2.018Ah	Time					
-0.63 <sup>2</sup> Current U • Batter Step 1 2	221 01 d.01 Init: AMP Init: AMP Init	C-Rate Cycle 1 1.455/h 01:33:24.521 789.000/h 00:05:00:012 2.025/h 05:03:40.443 113.961/µh	Cycle Line Cycle 2 2.026Ah 02:07:38,973 585:000Ah 00:05:00.007 2.025Ah 05:03:48.540 114:243.545	Current Graph Cycle 3 2.027Ah 02:06:59.617 60:05:00:012 2.023Ah 05:03:J0.930 113.843uAh	Voltage Grap Cycle 4 2.022Ah 02:07:03.805 814.060nAh 05:00.001 2.010Ah 05:02:03.815 913.5224Ah	Cycle 5 2.018Ah 02:07:13.327 635.000nAb 00:05:00.023 2.018Ah 05:02:49.027 113.8520Ah	Time					
-0.63 <sup>2</sup> Current U * Batter Step 1 2 3	221 01 d.01 Init: AMP ry Cycle Operation Charge Rest Discharge	C-Rate Cycle 1 1.455/Ab 01:33:24.521 759.000Ab 00:05:00.012 2.025Ab 05:03:4433	Cycle Line Cycle 2 2.026Ab 02:07:38.973 585.000Ab 00:05:00.007 2.025Ab 03:03:45.540	Current Graph Cycle 3 2.027Ah 02:05:59.617 595.000Ah 00:05:00.012 2.023Ah 05:03:10.930	Voltage Grap Cycle 4 2.022Ah 02:07:03.805 814.000Ah 00:05:00.001 2.010Ah 05:02:03.819	Cycle 5 2.018Ah 02:07-13.327 635.000Ah 06:05:00.023 2.018Ah 05:02:49.027	Time	01 d.07	C1 4.09	01 d 10		
-0.63 <sup>2</sup> Current U * Batter Step 1 2 3	221 01 d.01 Init: AMP ry Cycle Operation Charge Rest Discharge	C-Rate Cycle 1 1.455/h 01:33:24.521 789.000/h 00:05:00:012 2.025/h 05:03:40.443 113.961/µh	Cycle Line Cycle 2 2.026Ah 02:07:38,973 585:000Ah 00:05:00.007 2.025Ah 05:03:48.540 114:243.545	Current Graph Cycle 3 2.027Ah 02:06:59.617 60:05:00:012 2.023Ah 05:03:J0.930 113.843uAh	Voltage Grap Cycle 4 2.022Ah 02:07:03.805 814.060nAh 05:00.001 2.010Ah 05:02:03.815 913.5224Ah	Cycle 5 2.018Ah 02:07:13.327 635.000nAb 00:05:00.023 2.018Ah 05:02:49.027 113.8520Ah	Time	91 d.07	61 4.09	01 d 10		
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Figure 7. BV9210B Cycle testing an 18650 battery.



Settings			Voltage and Current	
Select Output: Operation Mode: Function:	1: N7951A • Discharge/Charge •	Charged Capacity 11.6797 Ah	1(A) 1(A) 1(A) 1(A) 1(A) 1(A) 1(A) 1(A)	Vt (V 3.86 3.80 3.72 3.00
Res	it Settings	<b>v</b> t 3.8000 v	16.00 6.07 3.33 1000 -0.000	3.5 3.5 3.4 3.3
<ul> <li>Settings</li> <li>Charging Mode:</li> <li>Current:</li> </ul>	💿 cc 🌑 cv 20 A	I 1.0164 A Charged Capacity		8:47 54:13
Max Battery Voltage:	3.8 V	Cepacity (Ah) 4 11.69018		
Cut-off Condition     Condition Type:	🖲 Current 💭 Voltage	11.67970 11.67922 11.67873		
Stopping Current:  Instrument Settings		11.67825 11.67777 11.67728		
	3.99 V	11.67680	54:06.013 54:07.013 54:08.013 54:09.013 54:10.013 54:11.013	
Datalog Settings			Time 🛱 🔍 Q	

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

•	💷 Battery Emulator 🔠 Battery Viewer		
=	Settings	Battery Status	Voltage and Current (Integration Period: 0.99962886)
Instrument Connection	Select Output: 1: No781A  Operation Node: Discharge/Charge  Function: Discharge	Depleted Capacity 4.4812 Ah Vt	1 (0) 1
Instrument Control	Reset Settings  Discharge Settings	1.0002 v I	0.07 0.08 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
Control	Diacharge Mode: Current Power Resistance	-1.0000 A Consumed Capacity	Current Unit: ● AMP C C Rate V Current Graph V Voltage Graph C Q Q Q P P T
A B C	Constant Current: 1 A Dyname Dyname Let Waveform Let Wav	Capacity (Ab) 5.224-010 3.72-010 2.246-00 2.246-00 7.56-00 7.56-00 9.2-0.53 3.040 0.12 2.55-30 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 3.040 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12	ି Ime ୮୭୦ ଲି ଷ୍ ପ୍ 🚼 🛃 🚺 📰
D	A Run Status: A- N6705C Stopped B- N	lo Instrument C- No Instrument D- No Instr	ument
C	Start 🕟 Start Al		ced Battery Test and Emulation 🔅 🖬 🐚 🚱 Export

**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	
	Low, 0.1 A	0.035% + 10 µA	
Current <sup>1</sup>	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, Curren Ripple and noise, Vpp (20 Hz to 2		0.01% + 250 μA	
Ripple and noise, Vpp (20 Hz to 2 Ripple and noise, Vrms (20 Hz to		< 7 mVpp < 600 µVrms	
	,	wing 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		· 00 μ3	
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	
Constant voltage mode	High, 60 V	0.03% + 15 mV	
	Low, 0.08 $\Omega$ to 30 $\Omega$	0.1% + 160 mS	
Constant resistance mode 2	Mid, 10 $\Omega$ to 1.25 k $\Omega$	0.1% + 16 mS	
	High, 100 $\Omega$ to 4 k $\Omega$	0.1% + 1.8 mS	
	Low, 0.02 W to 5 W	0.08% + 18 mW	
Constant power mode	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			
	Low, 4 A	0.05% + 820 µA	
Current	High, 40 A	0.05% + 7.2 mA	
	Low, 15 V	0.03% + 4.2 mV	
Voltage	High, 60 V	0.03% + 15 mV	
Davias	Low, 0.02 W to 5 W	0.08% + 18 mW	
Power	Mid, 0.15 W to 25 W	0.08% + 150 mW	
	High, 1.5 W to 250 W	0.08% + 1.2 W	

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.
 Does not apply to current setting < 0.05% of full-scale current, minimum voltage = 0.5 V.</li>



### **Typical characteristics**

		E36731A			
DC power supply characteris	stics				
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		
	Low, 0.1 A	1 µA	1 µA		
Current <sup>1</sup>	Mid, 2 A	1 mA	100 µA		
	High, 20 A	1 mA	300 µA		
Programmable output resista	ance				
Range		-50 m $\Omega$ to 1 k $\Omega$			
Accuracy					
Programming temperature c	oefficient per °C (% of output	: + offset)			
Voltage		0.01% + 0.6 mV			
Current		0.01% + 0.2 mA			
Readback temperature coeff	icient per °C (% of output + c	et)			
Voltage		0.01% + 0.04 mV			
Current		0.01% + 0.2mA			
Ripple and noise, normal mode	e current (20 Hz to 20 MHz)	< 1 mArms			
Remote sense (maximum volta	age in load lead)	0.7 V			
Over voltage protection (OVP)	programming accuracy	0.2% + 0.4 V	0.2% + 0.4 V		
Over voltage protection (OVP)	activation time <sup>2</sup>	< 5 ms	< 5 ms		
Over current protection (OCP)	activation time <sup>2</sup>	< 5 ms			
Up/down programming settli	ng time to within 1% of the t	otal 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
------------------------------------------------------------------------------

Typical minimum operating voltage at full-scale	ourrent and for fail dynamic	
Current	Low, 4 A	0.15 V
Current	High, 40 A	1.5 V
Programming resolution		
	Low, 4 A	45 µA
Constant current mode	High, 40 A	450 μΑ
	Low, 15 V	170 μV
Constant voltage mode	High, 60 V	1.7 mV
	Low, 0.08 $\Omega$ to 30 $\Omega$	450 µS
Constant resistance mode1	Mid, 10 $\Omega$ to 1.25 k $\Omega$	450 µS
	High, 100 $\Omega$ to 4 $k\Omega$	45 µS
	Low, 0.02 W to 5 W	675 μW
Constant power mode	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
Current	High, 40 A	700 µA
Voltage	Low, 15 V	270 μV
Voltage	High, 60 V	2.7 mV
Temperature coefficients - programming / read	back	
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
constant voltage mode	High, 60 V	0.006%/°C + 600 µV/°C
	Low, 0.08 $\Omega$ to 30 $\Omega$	0.01%/°C + 3 mS/°C
Constant resistance mode <sup>1</sup>	Mid, 10 $\Omega$ to 1.25 $k\Omega$	0.01%/°C + 250 µS/°C
	High, 100 $\Omega$ to 4 $k\Omega$	0.01%/°C + 25 µS/°C
	Low, 0.02 W to 5 W	0.015%/°C + 1 mW/°C
Constant power mode	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 2	0 MHz)	< 6 mArms
Measurement Small Signal Bandwidth (-3 dB typica	ai)	30 kHz
Measurement Small Signal Bandwidth (-1 dB typica	al)	17.5 kHz



### Typical characteristics (continued)

Programmable short / open		27.5 mO(4.0.40.0)
Programmable short Input off impedance		37.5 mΩ (4 A / 40 A) 824 kΩ
Electronic Load Characteristics		024 102
Protection		
	Low, 4 A	4.35 A ± 25 mA
Fixed OCP	High, 40 A	$42 \text{ A} \pm 250 \text{ mA}$
	Low, 4.08 A	0.2% + 50 mA
Programming OCP	High, 40.8 A	0.2% + 80 mA
	Low, 15 V	16.5 V +/- 85 mV
OVP	High, 60 V	165 V +/- 600 mV
	Low, 0.02 W to 5 W	5.5 W
OPP	Mid, 0.15 W to 25 W	27.5 W
	High, 1.5 W to 250 W	275 W
Protection activation time	Tigh, 1.5 W to 250 W	213 W
INH input		< 5 µs
Fault on coupled output		< 10 µs
Minimum programmable operating point		
	Low, 4 A	1 mA
Constant current mode	High, 40 A	10 mA
	Low, 15 V	5 mV
Constant voltage mode	High, 60 V	20 mV
	Low, 0.08 Ω to 30 Ω	0.08 Ω
Constant resistance mode <sup>1</sup>	Mid, 10 Ω to 1.25 kΩ	10 Ω
	High, 100 $\Omega$ to 4 k $\Omega$	100 Ω
	Low, 0.02 W to 5 W	0.02 W
Constant power mode	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	-	
	Low, 0.02 W to 5 W	5.1 W
Constant power mode	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	0% to 90% or 90% to 10%	
Constant constant and the	Low, 4 A	200 kA/s
Constant current mode	High, 40 A	3.7 MA/s
	Low, 15 V	79 kV/s
Constant voltage mode	High, 60 V	310 kV/s
Mainframe oscilloscope measurement accuracy	,	
Constant surrent mode	Low, 4 A	0.04% + 3 mA
Constant current mode	High, 40 A	0.04% + 10 mA
	Low, 15 V	0.02% + 15 mV
Constant voltage mode	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 The load lead drop reduces the maximum available voltage at the	
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 °C 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 °C (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 °C (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 °C (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	Step 2	Step 3	
Determine the software model	Choose license term	Select license type	
<ul> <li>Choose the right software model to automate all the connected power supplies.</li> <li>BV9211B: Allows only one instrument connection at a time.</li> <li>BV9210B: Allows up to four instrument connections at a time.</li> </ul>	Subscription	<ul> <li>Node-locked</li> <li>Transportable</li> <li>USB portable</li> <li>Floating – single site</li> </ul>	

Step 4 Select duration	Step 5 Select USB	Step 6 Select delivery method
<ul><li> 6 months</li><li> 12 months</li></ul>	Only for "USB portable"	<ul><li> Paper certificate</li><li> eMail and paper certificate</li></ul>
<ul><li> 24 months</li><li> 36 months</li></ul>		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

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.



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