X8712A IoT Device Battery Life Optimization Solution

Introduction

To get the most out of your IoT device's battery, you need to understand what RF and sub-circuit events are causing battery charge consumption. This will enable you to make the hardware and firmware programming decisions that will optimize your battery's runtime.

Battery, the Heart of IoT Devices

Wireless devices have increased by leaps and bounds over the years with the increasing adoption of wireless networking technologies across the globe. The demand for smart, connected devices is also fueling the growth of Internet-of-Things (IoT) devices market. As such, battery life, time to market and product reliability are now more crucial than ever.

For some medical or industrial IoT devices, life of users can be at stake if the battery does not live up to expectations. Some IoT devices do not have a low battery indicator, hence, users depend heavily on the warranted battery life specifications, making the battery life claim more crucial than ever. Hence, IoT device developers today face a monumental task starting from the product design up to design validation when it comes to estimating the device’s battery life and putting it down on paper for their customers.

Typical challenges include:

- How to measure the battery life to substantiate the battery life expectancy claim to customers?
- What are the critical events that contribute to the power consumption and when frequently these events happen? What is the power consumption profile of your device’s typical operating cycle?
- What design changes or tradeoffs to make to optimize battery life?
- How to solve all the above with the least amount of time to meet project schedule?

As an R&D engineer for IoT devices, you need tools to help you quickly obtain deeper insights into your device’s design so that you can accelerate troubleshooting and design verification tasks.

The New Way to Perform Battery Drain Analysis

How event-based power analysis works

To easily estimate the battery life of your new IoT device, firstly, you need to determine what are the sub-systems that make up your device; for example, RF radio, display, beeper, vibrator etc., and how much current each sub-system will draw until your device's battery runs out.

The X8712A helps you determine the total power consumption of your device using the powerful Keysight X8712A-DPA DC power analyzer and its Source Measure Unit (SMU) and electronic load modules, RF event detector together with the KS833A2A PathWave event-based power analysis software. It captures RF and/or DC events from your IoT device, synchronously match the events to the current consumption and estimates the battery life of your device.

Figure 1. The X8712A consists of the X8712A-DPA DC power analyzer, source measure units, electronic load modules, X8712AD RF event detector and the KS833A2A PathWave event-based power analysis software.

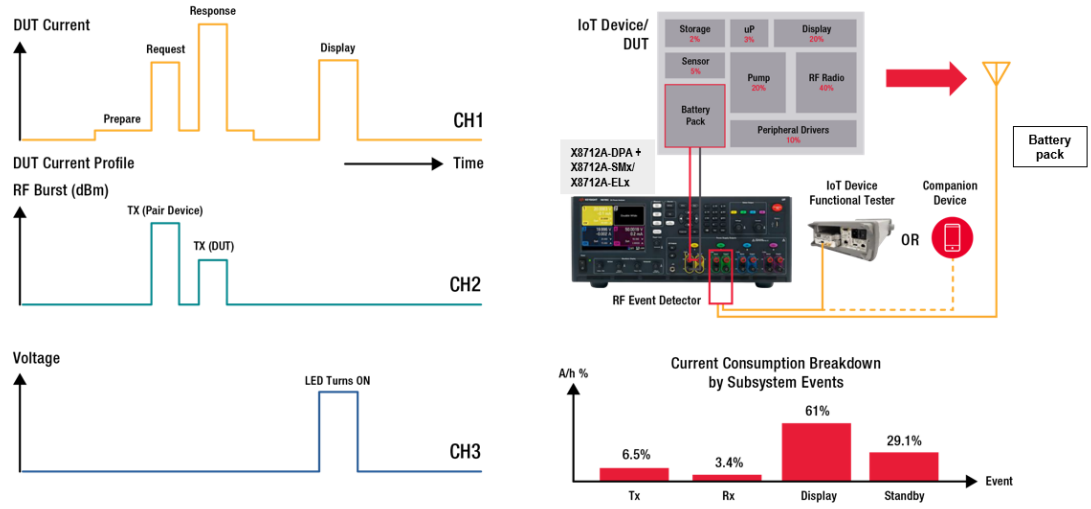

Figure 2. The X8712A event-based power analysis concept

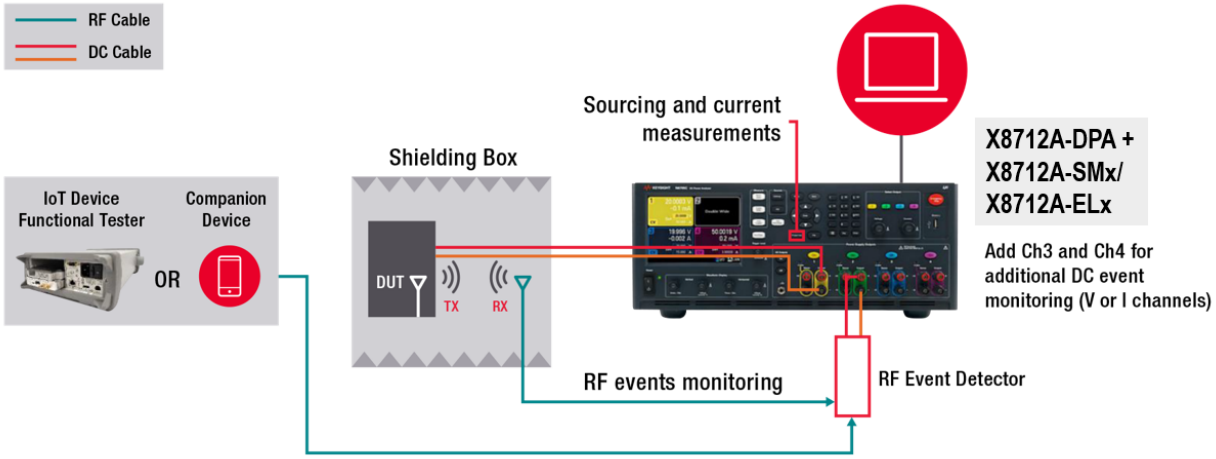

Figure 3. The X8712A synchronizes and correlates current consumption with RF/DC events

X8712A-DPA DC power analyzer, Source Measure Units (SMUs) and DC electronic load modules

The N6705C DC power analyzer can measure DC voltage and current to and from the device under test (DUT). The SMU modules consist of battery emulators tailored for powering IoT devices (up to 80 W) and measuring current drain from nA to A using patented seamless current ranging technology, while the DC electronic load modules are used for event monitoring.

KS833A2A PathWave event-based power analysis software

The KS833A2A PathWave event-based power analysis software provides an easy-to-use visualization tool to help you analyze the data acquired with the X8712A-DPA DC power analyzer, SMU or electronic DC load modules. It provides a visual representation of the RF signals of your IoT device in dB or non-RF signals in DC voltage measurements and maps these signals to the current measurement in a single graph.

Features

- Automated correlation between RF or DC signals to power consumption in a single display
- Three types of waveform capture modes; single, triggered, and continuous
- Individual event's post data analysis
  - Current consumption in percentage
  - Occupied time in percentage
- Battery life estimation
- CCDF statistical analysis
- User defined measurement duration time (for continuous mode only)
- Save and recall settings which includes instrument settings.
- Export data points from UI and measurement results in .csv format.

Figure 4. Overview of the KS833A2A event-based power analysis software

Key Benefits of the X8712A

1. Detect design weaknesses with quick and effortless event-based power consumption analysis

The X8712A automatically correlates critical RF or DC events of your device to the power consumed, down to the sub-system or events level. With this capability, you can identify the events or sub-systems that are consuming the most current and optimize it accordingly to meet the battery life requirements.

With its wide dynamic range current measurement from nA to A and fast 20 µs sampling rate, the X8712A is also able to accurately capture the dynamic current consumption of your device as it transitions between different operating states, from sleep/idle mode drawing the least current to active transmitting mode drawing the most.

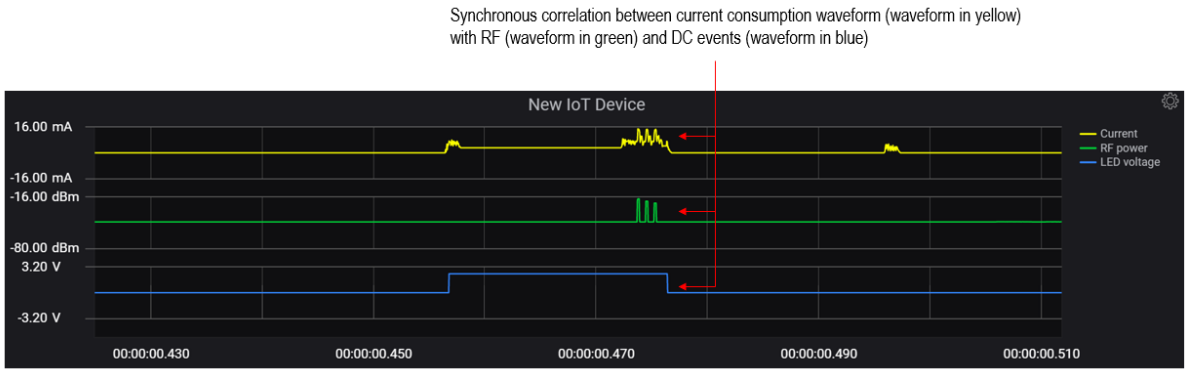

Figure 5. DC (blue), RF (green), and current (yellow) measurements are synchronized

Data logging modes

The KS833A2A offers three data logging modes to fit your varying application needs. The available modes are single, triggered and continuous.

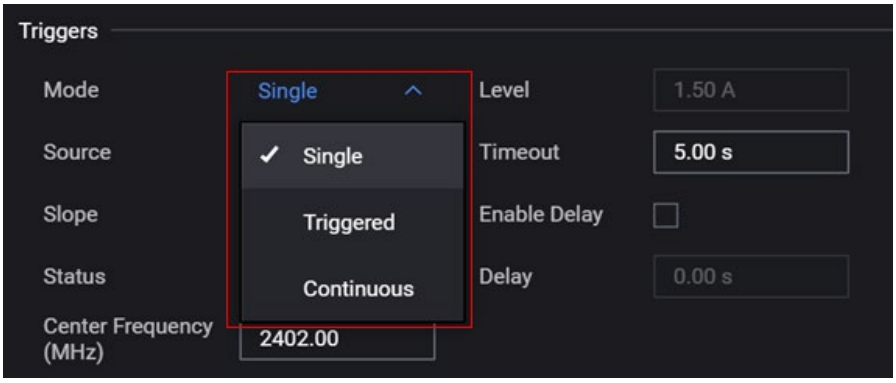

Figure 6. Choose the data capture mode that suits your measurement needs

Single mode

The single mode is recommended to capture high fidelity information such as RF events occurring in the hundreds of microseconds (5.12uS for one channel and 20.48uS for 4 channels) as it provides the ability to analyze fast events with a lot of details.

Triggered mode

To effectively know when a particular RF or DC event occurs, the X8712A provides triggering function for each channel so that you will be able to capture and analyze that event and the current consumed.

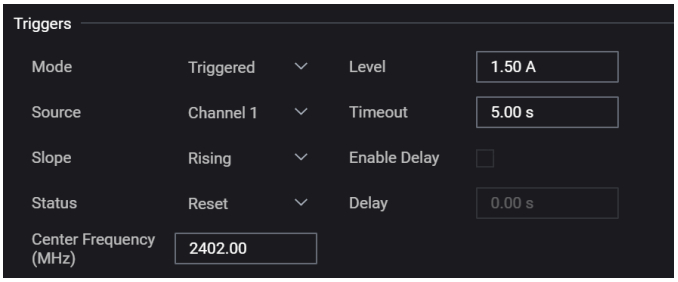

Figure 7. Use the trigger function to capture an event of interest

Continuous mode

The continuous mode is recommended to capture very large amounts of data (up to 8 days) with lower fidelity (102.4uS for every channel and 409.6uS for four channels) compared to single mode.

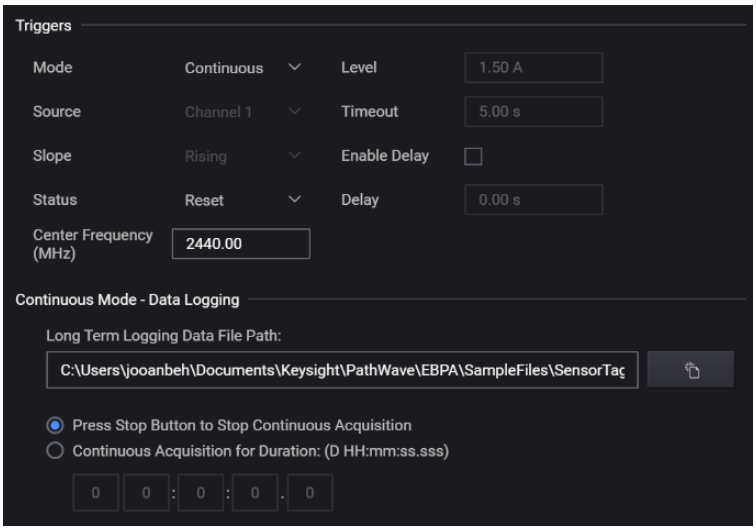

Figure 8. Use the continuous mode function to see your device's charge consumption profile over several days

For more information on the data capture modes, please refer to the event-based power analysis software's help file (marked as '?' at the top of the software), under this section: Event Based Power Analysis > Getting Started > User Interface Tour > Heading bar > Configuration Panel > Triggers.

In-depth current analysis

The KS833A2A provides post measurement analysis where you can further analyze the current consumption for a subsystem which you are interested in.

RF or DC events analysis

You can adjust the upper and/or lower trigger threshold levels in order to define events based on the signal level that you have obtained in the waveform display.

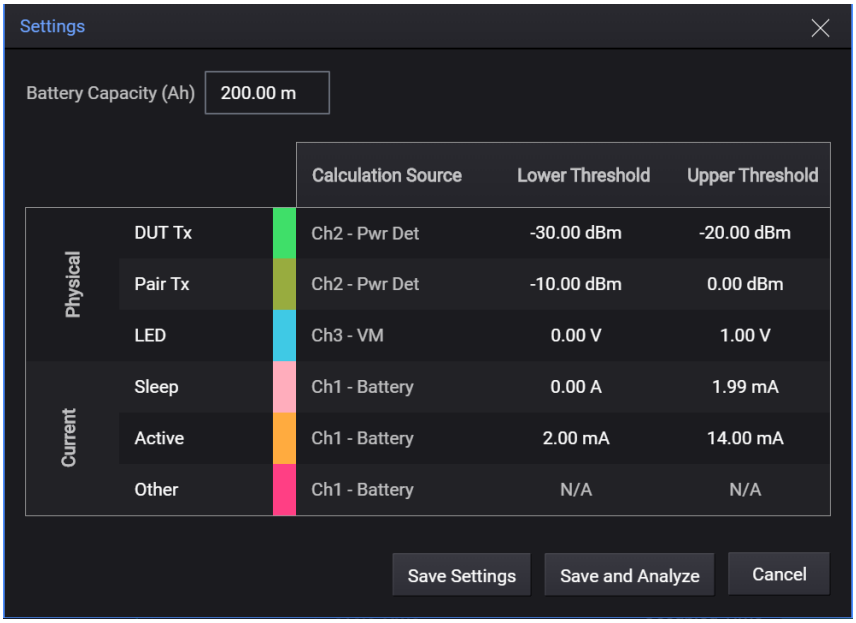

Figure 9. Define events based on the signals measured in channels 2, 3, and 4

Based on the threshold settings, the software will instantly calculate the event's occupied time and current consumption in % (see Figure 10).

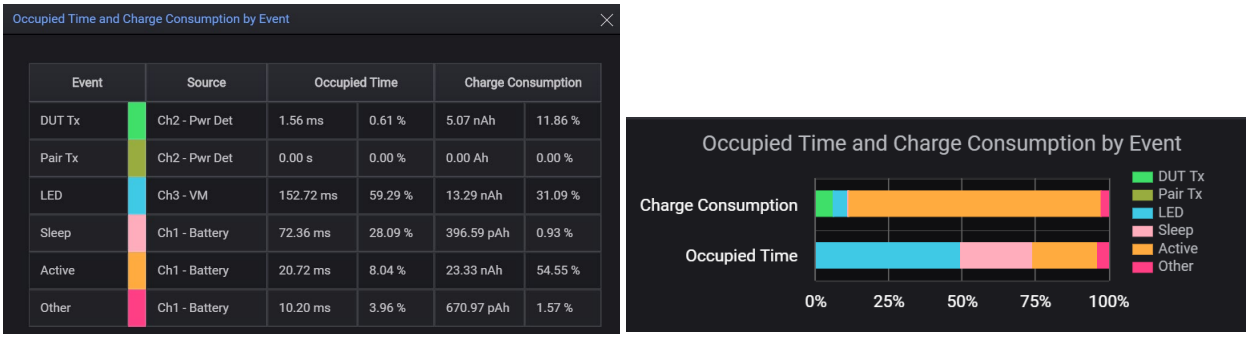

Figure 10. Obtain an RF or DC event's occupied time and charge consumption in %

This helps you identify the subsystem(s) for improvement to optimize battery life.

Complementary Cumulative Distribution Function (CCDF) statistical analysis

The KS833A2A provides CCDF profiles of a selected area to help you analyze distribution profiles. This function provides a concise way to display long-term dynamic random current drain. It is also an effective way to quantify the impact of design changes—hardware, firmware or software— on current flows in your device.

Since the CCDF profiles have identical behavior on each activity of the device, the profiles can also be leveraged in production testing even with different test instruments to check on device performance.

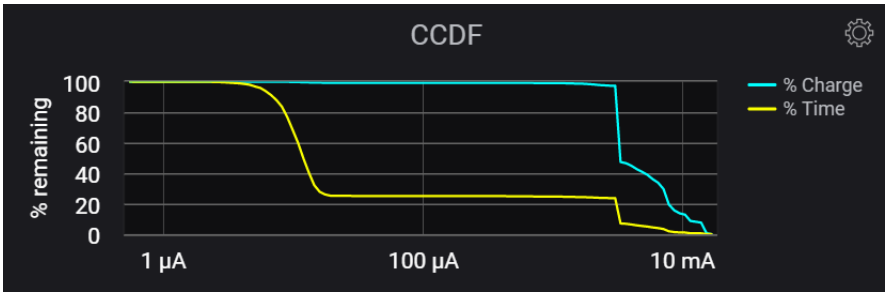

Figure 11. Complementary Cumulative Distribution Function (CCDF).

RF or DC events analysis

You can adjust the upper and/or lower trigger threshold levels in order to define events based on the signal level that you have obtained in the waveform display.

2. Easily estimate battery life

When measuring the power consumption at the sub-system level, the KS833A2A Event-based Power Analysis software calculates the RF or DC event's occupancy time and current consumption contribution in percentage and presents the information in a tabular and chart format. For homogenous signals, this allows you to easily obtain the estimated battery life in hours, in a very short time.

By specifying the battery capacity and area of interest (select specific graph using the region tags), the KS833A2A will display the estimated battery life.

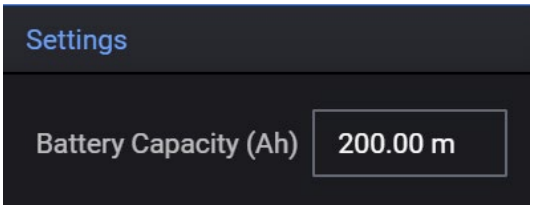

Figure 12. Specify your battery's capacity to get estimated battery life based on the charge consumption profile

Figure 13. Battery life predicted based on four full operational cycles and 0.2-Ah battery capacity

The X8712A also enables over-the-air signaling DUT monitoring in various real-world operating modes to predict the battery life in real-world operations. This applies to devices with radio formats below 3 GHz. With this, you will be able to simulate the worst-case scenario (like temperature, humidity etc.) to accurately confirm on the life expectancy of your DUT's battery.

X8712A Key Characteristics

Feature	Description
Number of channels supported	Up to 4 Channel 1: Battery emulator Channel 2: RF power detector Channel 3 & 4: voltmeter/ammeter/power supply)
Measurement mode types	Single, triggered, and continuous on all channels

	Number of active channels			
	1	2	3	4
Single and triggered modes				
Max. sample size	524,288	262,144	131,072	65,536
Min. time interval	5.12 µs	10.24 µs	20.48 µs	20.48 µs
Max. time interval	100 ms			
Continuous mode				
Min. time interval	102.4 µs	204.8 µs	307.2 µs	409.6 us
Max. time interval	100 ms			

The length of a data acquisition in this mode will be determined by your PC's storage space availability.

Type	Module	Voltage range	Current limit	Modes	Use in channel	
					Channel 1: Sourcing/ measurement	Channel 2 to 4: monitoring
Source/measure unit	N6781A	+ 20 V/ 6 V	±1 A/ ±3 A	VM, AM and 2-QPS	Yes	Yes
	N6782A				Yes	Yes
	N6784A				No	Yes
	N6785A (double-wide power module)	20 V/ 15 V/ 10 V/ 6 V	±4 A/ ±5 A/ ±6.7 A/ ±8 A		Yes	Channel 3 only
	N6786A* (double-wide power module)				Yes	Channel 3 only
DC electronic load	N6791A	0 to 60 V	0 to 20 A	VM and AM	No	Yes
	N6792A (double-wide power module)		0 to 40 A		No	Channel 3 only

RF Event Detector Characteristics

Feature	Description
Operation frequency range	100 MHz to 2.9 GHz
Dynamic range	40 dB typical
Power measurement range	-40 to 0 dBm
Power accuracy (typical)	1.9 GHz to 2.6 GHz: +/-1.5 dB 100 MHz to 1.9 GHz, 2.6 GHz to 2.9 GHz: +/-3 dB Without power coefficient inputs*: +/-5 dB
Maximum input damage power	+15 dBm
DC power	5 V @ 30 mA by micro-USB adapter

* These are slope and intercept values that come with each RF detector which provide power accuracy improvement over certain frequency ranges. Follow the instructions in the X8712-90008 flyer to enter these values into the KS833A2A event-based power analysis software.

PC Requirements

The following are the minimum requirements for a PC to be used with the X8712A solution.

Processor	: Intel i5 x64
RAM	: 8GB
Resolution	: 1366 x 768
Operating System	: Windows 10

X8763A RF shielded enclosure

To complement the X8712A solution, Keysight offers the ordering convenience of adding an RF shielded enclosure, the X8763A, manufactured and warranted (one year) by BIP Roottek.

The X8763A provides:

- High performance RF absorber
- Highly effective shielding using double layer gasket structure
- Small grid plate with on-board screw holes, fixture, antenna coupler (Wide band with VSWR < 2.2 at 0.8 ~ 6GHz) and I/O panel (C-DB25 1000, C-USB 2.0, 2x C-N-SMA 4H)

RF shielding effectiveness

The shield effectiveness below is measured when the blank panel is mounted.

Range	Shield effectiveness
100 to 3000 MHz	> 70 dB
3000 to 6000 MHz	> 60 dB

Net weight	
Weight	Approx. 7.6 Kgf
Dimensions	
Width x depth x height	Inside: 173 (W) x 248 (D) x 134 (H) mm Outside: 248 (W) x 305 (D) x 212 (H) mm, lid closed. 394 (D) x 409 (H) mm, lid open

Ordering Information

At least one hardware selection must be made. The KS833A2A PathWave event-based power analysis software is mandatory.

Model numbers	Description	Quantity
X8712A-RFD	X8712AD RF event detector	1
X8712A-DPA	N6705C DC power analyzer, modular, 600 W, 4 slots	1
X8712A-SMU	N6781A 2-quadrant source/measure unit for batterydrain analysis, 20 V/1 A or 6 V/3 A, 20 W	Up to 4
X8712A-SM2	N6782A source/measure unit for functional test, 2-quadrant, 20 V/1 A or 6 V/3 A, 20 W	Up to 4
X8712A-SM4	N6784A 4Q general-purpose source/measure unit, 20 V/1 A or 6 V/3 A, 20 W	Up to 3
X8712A-SM6	N6786A source/measure unit for functional test, multiple ranges, 80 W, double-wide	Up to 2
X8712A-SM8	N6785A 2-quadrant source/measure unit for battery drain analysis, multiple ranges, 80 W, double-wide	Up to 2
X8712A-EL1	N6791A module, 100 W, single-wide	Up to 3
X8712A-EL2	N6792A module, 200 W, double-wide	1
KS833A2A	PathWave event-based power analysis software	1

Examples of Two-Channel Configurations

Option number	Description	Quantity
Hardware		
X8712A-DPA	N6705C DC power analyzer, modular, 600 W, 4 slots	1
X8712A-SMU	N6781A 2-quadrant source/measure unit for battery drain analysis, 20 V, ±1 A or 6 V, ±3 A, 20 W	2
X8712A-RFD	X8712AD RF event detector	1
Software		
KS833A2A	PathWave event-based power analysis software	1

Or

Option number	Description	Quantity
Hardware		
X8712A-DPA	N6705C DC power analyzer, modular, 600 W, 4 slots	1
X8712A-SMU	N6781A 2-quadrant source/measure unit for battery drain analysis, 20 V, ±1 A or 6 V, ±3 A, 20 W	1
X8712A-SM8	N6785A 2-quadrant source/measure unit for battery drain analysis, multiple ranges, 80 W, double-wide	1
X8712A-RFD	X8712AD RF event detector	1
Software		
KS833A2A	PathWave event-based power analysis software	1

Examples of a Four-Channel Configuration

Option number	Description	Quantity
Hardware		
X8712A-DPA	N6705C DC power analyzer, modular, 600 W, 4 slots	1
X8712A-SMU	N6781A 2-quadrant source/measure unit for battery drain analysis, 20 V, ±1 A or 6 V, ±3 A, 20 W	4
X8712A-RFD	X8712AD RF event detector	1
Software		
KS833A2A	PathWave event-based power analysis software	1

KS833A2A Software – License Types and Terms

Time-based software license and support subcription	
SW1000-SUB-01	Software subscription

Accessories

Model number	Description
X8763A	RF shield enclosure kit Suitable for small device under tests. Includes I/O panel, antenna coupler, grid fixture and RF cable

Related Information

For more information on the X8712A, please visit: www.keysight.com/find/X8712A.

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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