

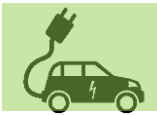
新能源汽车中高压瞬态特征的模拟

吕宝华、饶骞

2024年1月5日



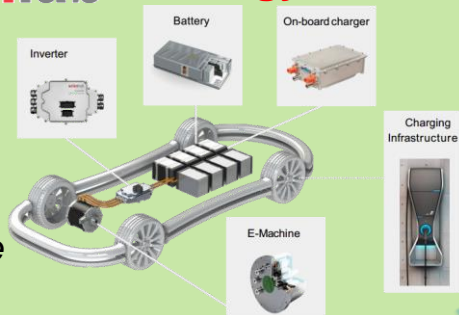
聚焦电动汽车和新能源，提供全面解决方案



New Energy

KEYSIGHT TECHNOLOGIES + scienlab = Energy solutions

BMS
Battery
Inverter
OBC
Charing Infrastructure



KEYSIGHT TECHNOLOGIES = Comprehensive Solutions

Radar
eCall
Car Ethernet
VDT
And More...



Autonomous Driving

KEYSIGHT TECHNOLOGIES = Leading brand



Mobile Chipsets Devices Network Access Core Network Data Center



Connected Car

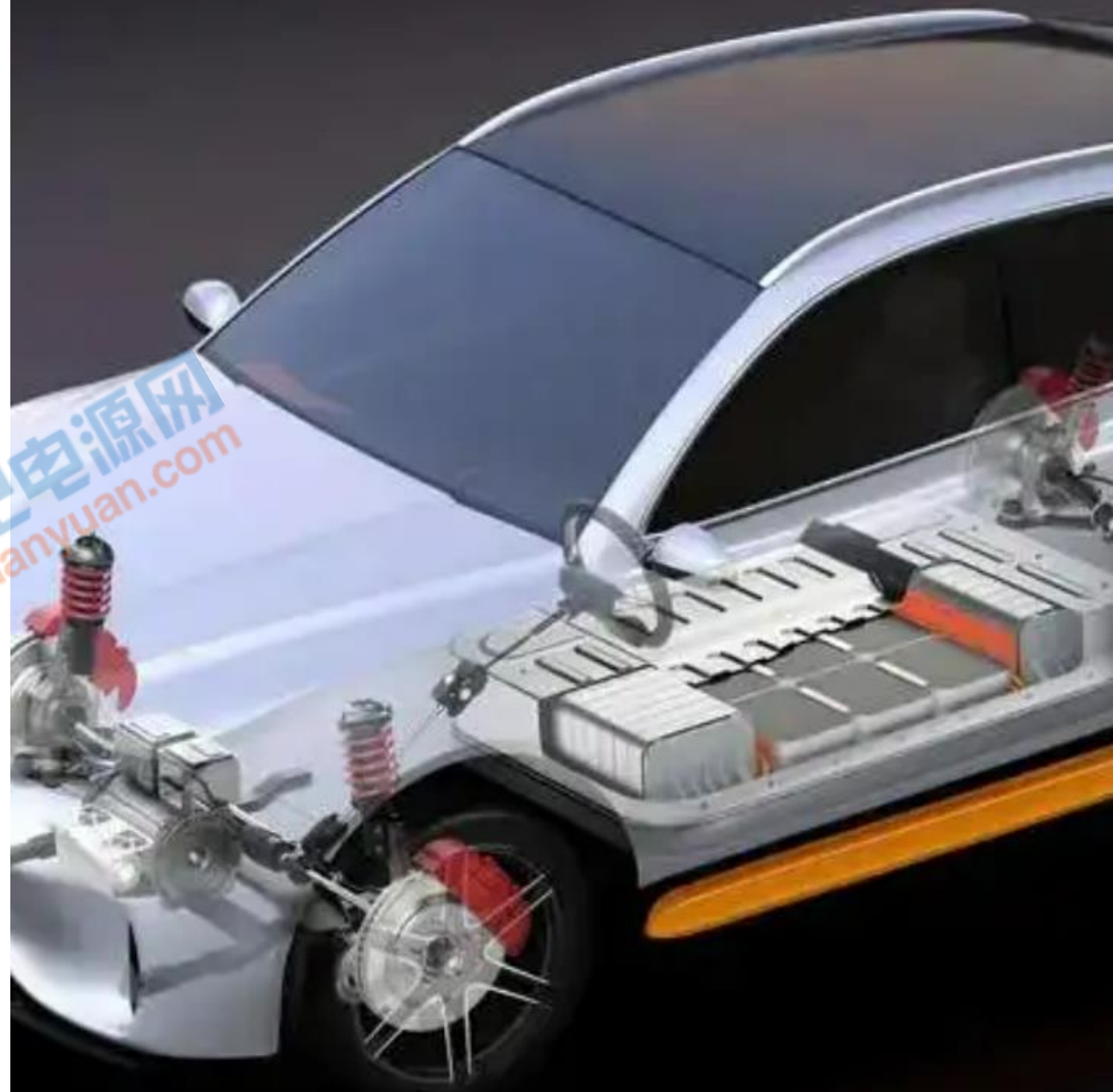


2014年，建立汽车和能源事业部AES
(Automotive & Energy Solution)
上海汽车城共建实验室

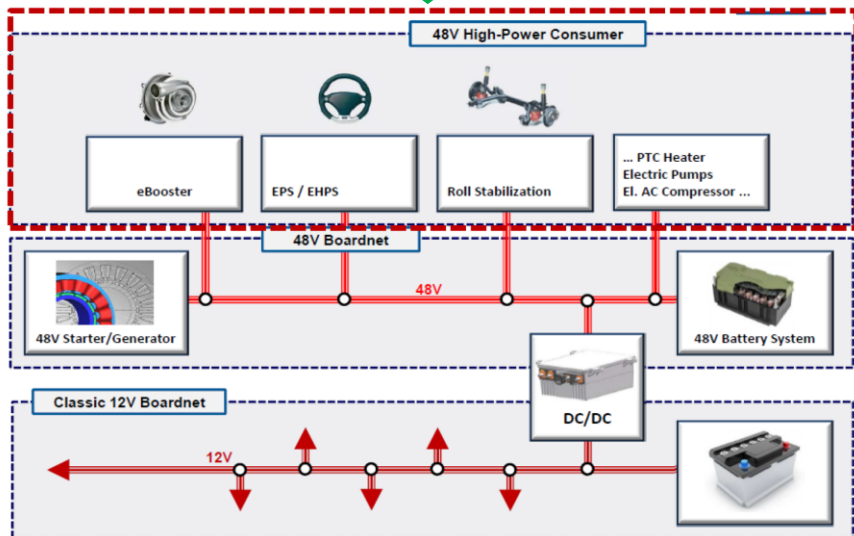
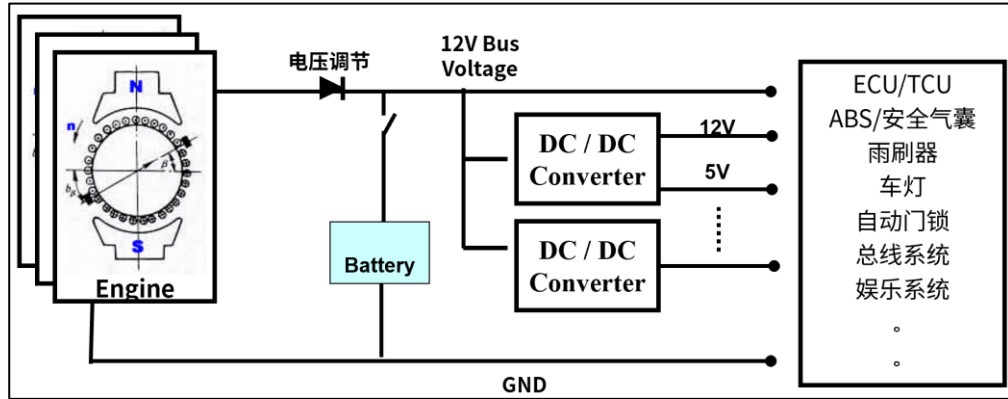
内容

- 汽车供电环境适应性要求
- 供电环境适应兼容性测试和真实状态
- 供电环境瞬态模拟的方案构建
- 演示

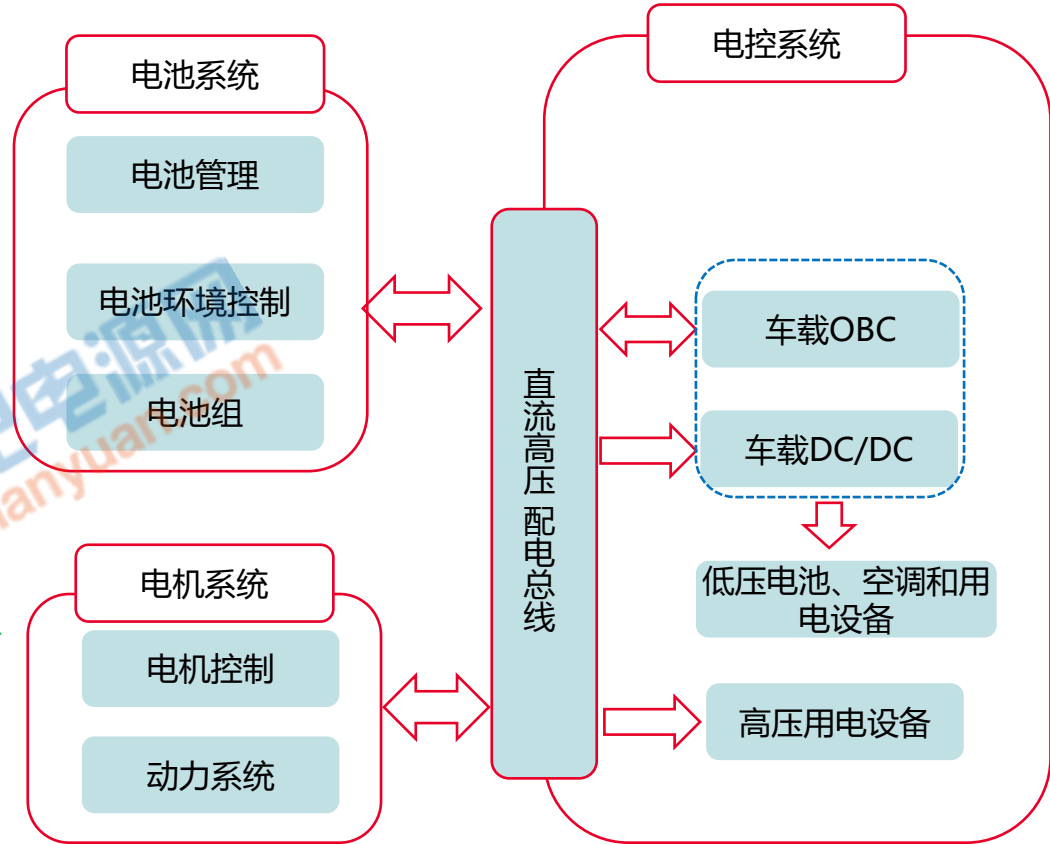
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传统、新能源汽车的电力电子系统



48V



汽车供电环境适应性要求和验证

汽车供电环境测试行业标准

ISO 16750-2

ISO 7637-2

JASO D001-94

SAE J1113-2, 4, 11, 12, 13

其他

企业标准

VW80000

Ford FMC 1278

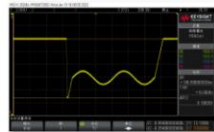
Nissan 24800 NDS 02, 03, 05, 07

LV 124, 148

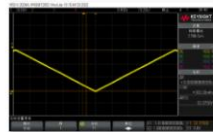
LV123

其他

INTERNATIONAL STANDARD **ISO 16750-2**
Road vehicles — Environmental conditions and testing for electrical and electronic equipment —
Part 2:
Electrical loads



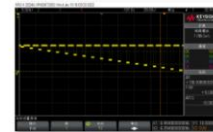
ISO16750-453-12V-T



ISO16750-44-24V



ISO16750-451-24V



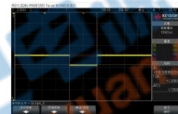
ISO16750-452-24V



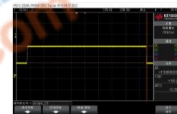
LV124-E01



LV124-E02



LV124-E03



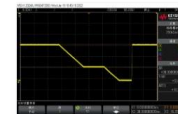
LV124-E04



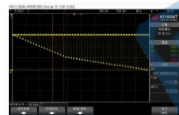
LV124-E05



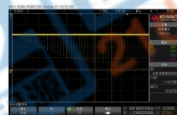
LV124-E07



LV124-E08



LV124-E09-TC1



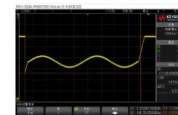
LV124-E09-TC2



LV124-E10



LV124-E10-N6784A



LV124-E11-TC1-Nor



LV124-E11-TC2



LV124-E12-TC1



LV148-E01A



LV148-E01B



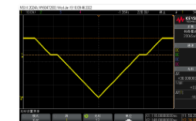
LV148-E02



LV148-E03



LV148-E04



LV148-E06A



LV148-E06B



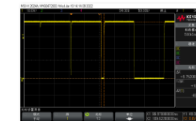
LV148-E07



LV148-E08-TC1



LV148-E08-TC2



LV148-E09



LV148-E10

电压范围定义和评价标准

UN = 12V		
Code	Umin	Umax
A	6	16
B	8	16
C	9	16
D	10.5	16

UN = 24V		
Code	Umin	Umax
E	10	32
F	16	32
G	22	32

Dynamic Overvoltage	— 60V
Static Overvoltage	— 54V
Limited Operation	— 52V
Unlimited Operation	48V
Limited Operation	— 36V
Undervoltage	— 24V
Storage Protection	— 20V

	HV Operating Status	HV1_1	HV2_2a	HV_2b
Upper HV circuit Limit	B3 or B4	220V	410V	430
Max Voltage Dynamic Load Dump	B3	+/-250V/ms		
Undervoltage	B3	<60V	<90V	<150V

ISO16750 12V /24V

LV148

LV123

LV 124

Functional status A

The DUT must fulfill all functions during and after exposure to the test parameters.

Functional status B

The DUT must fulfill all functions during exposure to the test parameters; however, one or more functions can lie outside the specified tolerance. After exposure to the test parameters, the DUT must automatically achieve functional status A again.

Functional status C

The DUT does not fulfill one or more functions during exposure to the test parameters.

After exposure to the test parameters, the DUT must automatically achieve functional status A again. Undefined functions are not permissible at any time.

Functional status D

The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must achieve functional status A again by means of a terminal changeover, a reset, or a simple intervention (e.g., replacement of a defective fuse). Undefined functions are not permissible at any time.

Functional status E

The DUT does not fulfill one or more functions during exposure to the test parameters and must be repaired or replaced after exposure to the test parameters. The device under test (DUT) must comply with the requirements for nonflammability as per UL94-v0.

LV 148

Functional status A

The DUT must fulfill all functions during and after exposure to the test parameters.

Functional status B

The DUT must fulfill all functions during exposure to the test parameters; however, one or more functions can lie outside the specified tolerance. After exposure to the test parameters, the DUT must automatically achieve functional status A again.

Functional status C

The DUT does not fulfill one or more functions during exposure to the test parameters.

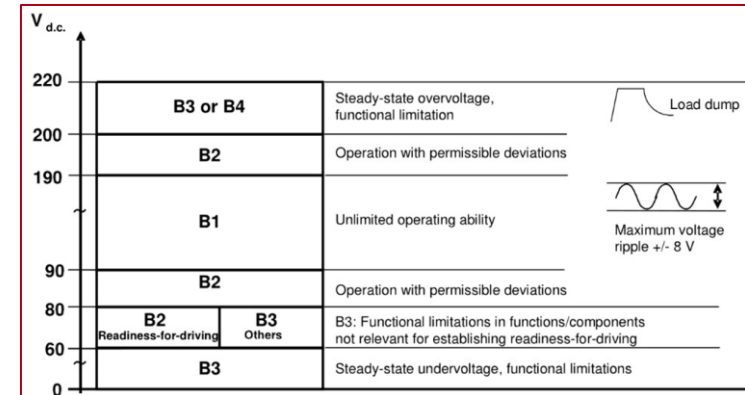
After exposure to the test parameters, the DUT must automatically achieve functional status A or B again. Undefined functions are not permissible at any time.

Functional status D

The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must achieve functional status A again by means of a terminal changeover, a reset, or a simple intervention (e.g., replacement of a defective fuse). Undefined functions are not permissible at any time.

Functional status E

The DUT does not fulfill one or more functions during exposure to the test parameters and must be repaired or replaced after exposure to the test parameters. The device under test (DUT) must comply with the requirements for nonflammability as per UL94-v0.



供电环境适应性的测试和等级

在实验室模拟实际现场可能会发生的电压波动，对产品进行“抗干扰”性能评估，确保产品能够在实际环境中正常工作及性能。

等级	在施加骚扰期间	在施加骚扰之后
一级 / A	能执行其预先设计的所有功能	
二级 / B	有一项或多项指标超出规定的偏差	自动恢复到正常工作范围内
三级 / C	不执行其预先设计的一项或多项功能	能自动恢复到正常操作状态
四级 / D	不执行其预先设计的一项或多项功能	需要通过简单的“操作或使用”复位动作，才能自动恢复到正常操作状态
五级 / E	不执行其预先设计的一项或多项功能	如果不修理或不替换装置或系统，则不能恢复其正常操作。



测试标准和测试项目比较

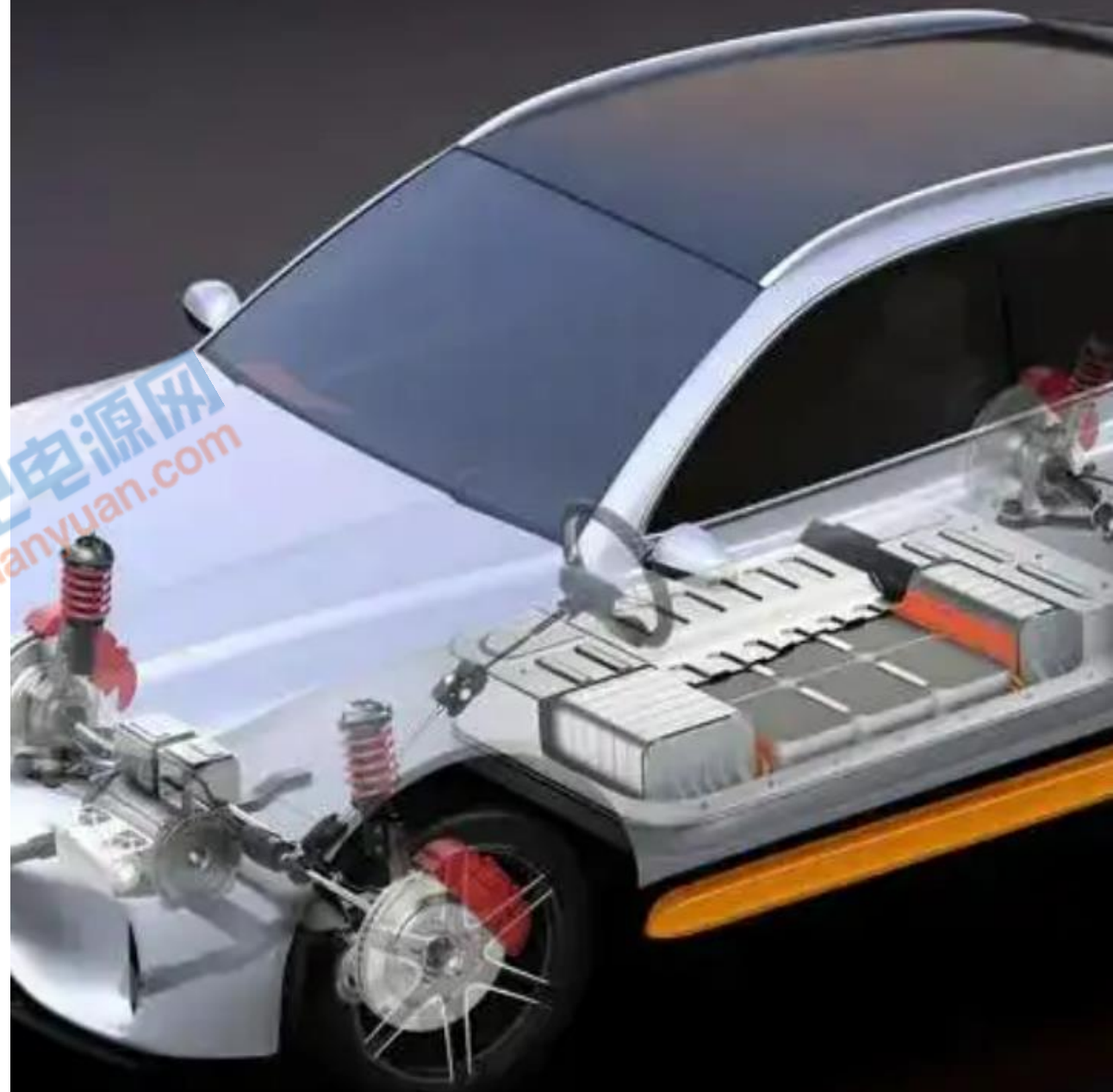
LV124	LV148	ISO16750
E-01 Long-term overvoltage	E48-01a,b Long-term overvoltage	4.2 Over Voltage
E-02 Transient overvoltage	E48-02 Transient overvoltage	4.3 Superimposed alternating voltage
E-03 Transient undervoltage	E48-03 Transient undervoltage	4.4 Slow decrease and increase of the supply voltage
E-04 Jump start	E48-04 Jump start	4.5 Discountined in power supply
E-05 Load dump	E48-05 Superimposed alternating voltage	4.5.1 Momentary drop in power supply
E-06 Superimposed alternating voltage	E48-06a,b,c Slow decrease and increase of the supply voltage	4.5.2 Reset behavior at voltage drop
E-07 Slow decrease and increase of the supply voltage	E48-07 Slow decrease and increase of the supply voltage	4.5.3 Starting profile
E-08 Slow decrease, quick increase of the supply voltage	E48-08 Reset behavior	4.6 Reverse voltage
E-09 Reset behavior	E48-9 Short interruptions	4.7 Open circuit test
E-10 Short interruptions	E48-10 Start pulses	4.8 Short Circuit protection
E-11 Start pulses	E48-11 Masseverlust BN48	4.9 Withstand Voltage
E-12 Voltage curve with electric system control	E48-12 Ground offset	4.10 Insulation resistance
E-13 Pin interruption	E48-13 Internal dielectric strength	4.11 Electromagnetic compatibility
E-14 Connector interruption	E48-14 Closed-circuit current	ISO7637
E-15 Reverse polarity	E48-15 Operation in range without function limitation	5.6.1 Test pulse 1
E-16 Ground offset	E48-16 Operation in the upper range with function limitation	5.6.2 Test pulses 2a
E-17 Short circuit in signal circuit and load circuits	E48-17 Operation in the lower range with function limitation	5.6.2 Test pulses 2b
E-18 Insulation resistance	E48-18 Overvoltage range	5.6.3 Test pulses 3a / 3b
E-19 Closed-circuit current	E48-19 Undervoltage range	5.6.4 starting profile
E-20 Dielectric strength	E48-20a Fault current Teil 1, Teil 2	5.6.5 load dump
E-21 Backfeeds	E48-21 Short circuit in signal circuit and load circuits	
E-22 Overcurrents		

测试项目大同小异， 波形定义区别！

内容

- 汽车供电环境适应性要求
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- 供电环境瞬态模拟的方案构建
- 演示

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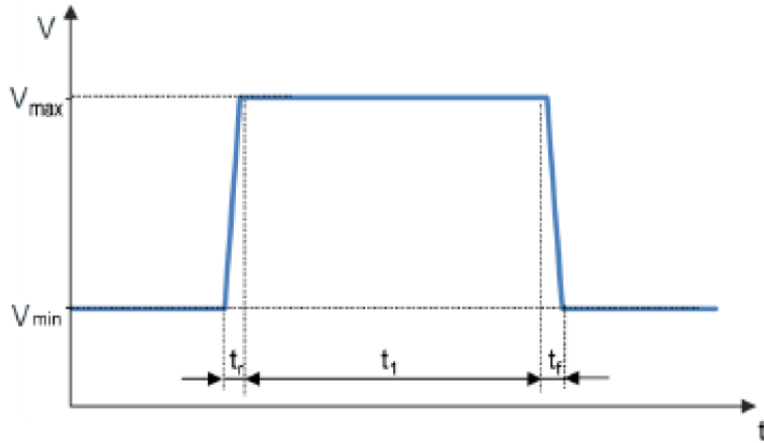


波形的定义和重要参数

E01 Long-term overvoltages

Aim: The component's resistance to long-term overvoltage is tested. A generator control fault during driving operation is simulated.

DUT operating mode	Operating mode II.c
V_{max}	17 V (+4%, 0%)
V_{min}	13,5 V
t_r	<10 ms
t_f	<10 ms
t_1	60 min
T_{test}	$T_{max} - 20$ K
Number of cycles	1
Number of DUTs	At least 6

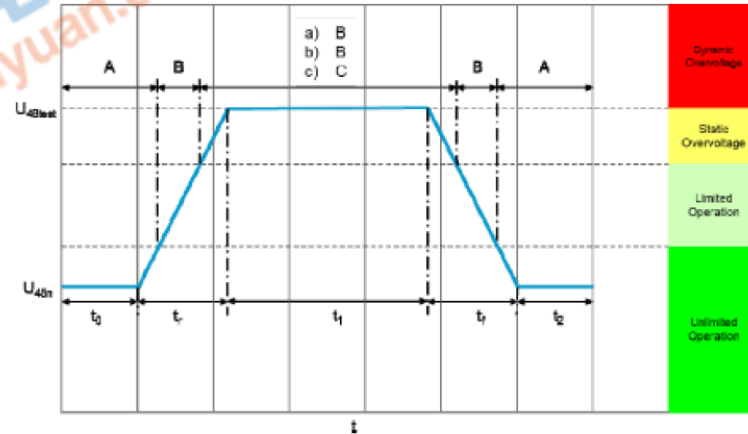


Requirements:

Components necessary for driving operation: Functional status B
For all other components: Functional status C

E48-01a Long-term overvoltages

Betriebsart des Prüflings	Betriebsart II.a, II.b und II.c
t_0	Funktionszustand A eingenommen
t_r	0,1 s
t_1	60 min
t_f	0,1 s
t_2	1 s
U_{48test}	$U_{48r,dyn}$
T_{test}	$T_{max} - 20$ °C
Anzahl der Zyklen	1
Anzahl der Prüflinge	6

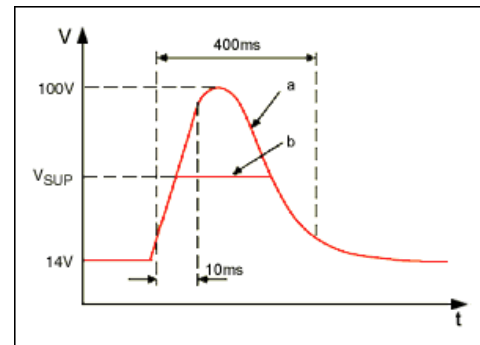
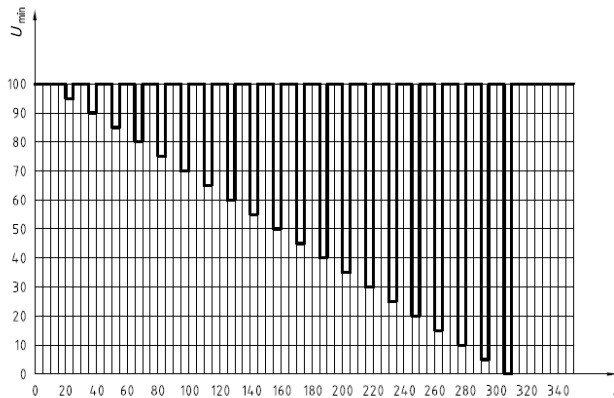
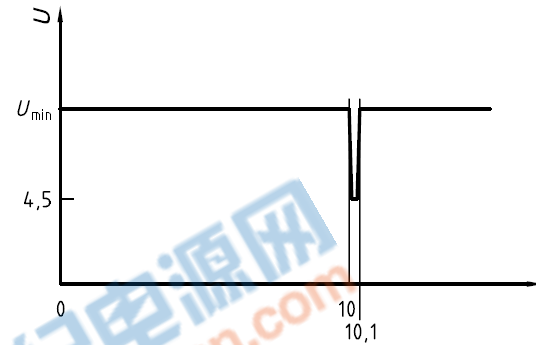
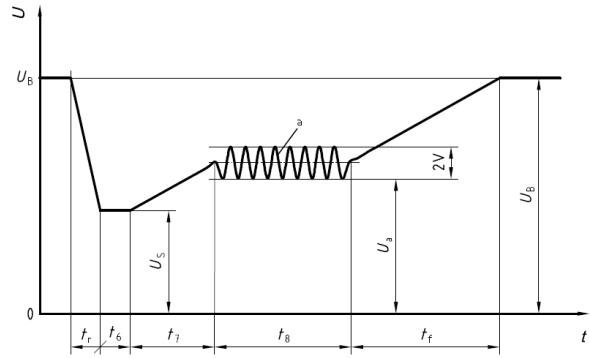


Requirements:

Components which convert electrical energy: Functional status B
Components necessary for driving operation: Functional status B
For all other components: Functional status C

波形定义与实际工作场景的关系

波形定义的依据



电压波形与实际工作场景分析1

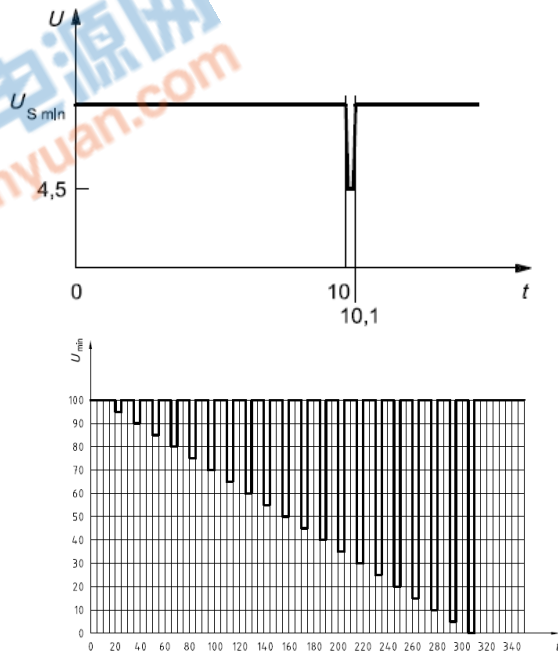
短时间电源跌落或中断

存在的问题

- 在某个车载产品短路、或者保险丝熔断导致瞬间电流过大引起的电压跌落甚至中断
- 在熔断过程中会造成电压的瞬间跌落，形成负电压脉冲，对周围的其他用电设备产生供电中断影响
- 为了保证关键车载电子、如行程控制器、ECU等的稳定性、产品必须对该电压跌落有免疫能力，**不能出现重启、死机等现象。**

模拟场景

- 保险丝熔断、接触松动时，对周围电路供电的影响



电压波形与实际工作场景分析2

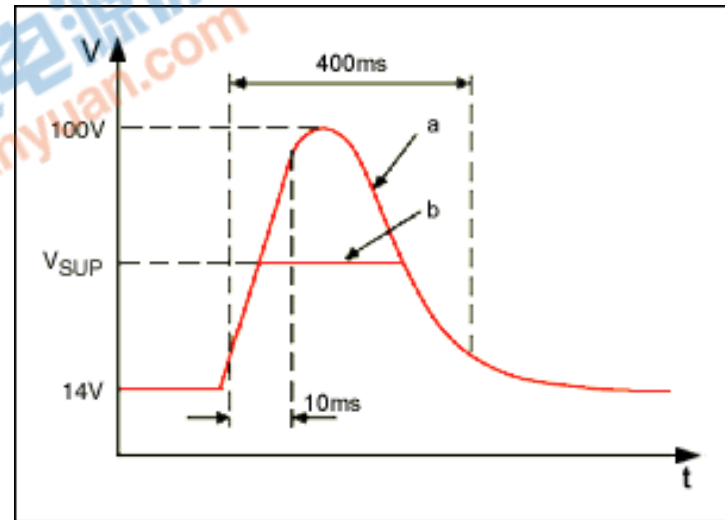
瞬间电压过冲或浪涌

存在的问题

- 汽车中除了纯阻性负载外，还有大量的感性负载，抛负载可能造成供电总线出现数倍的电压脉冲
- 负载脉冲一般上升沿在1毫秒到10毫秒之间，宽度约为50-400毫秒
- 如助力转向电器，雨刮器等。当这些负载失效的瞬间，通常会伴随着较高的感应电动势，引起供电线路瞬高电压。
- 工程师需要验证其设计车载电子产品在该“抛负载”电压的性能，不出现重启、死机、甚至损坏。

模拟场景

- 模拟感性负载故障时，对周围电路供电的影响

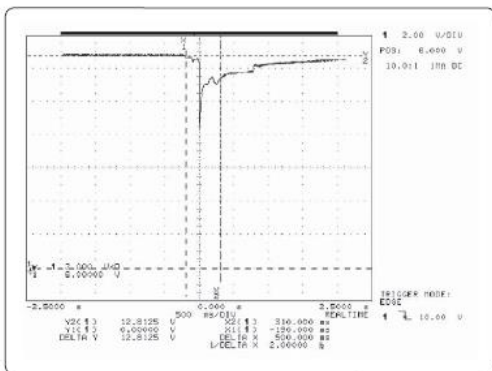


电压波形与实际工作场景分析3

发动机启动瞬间电压瞬变波形

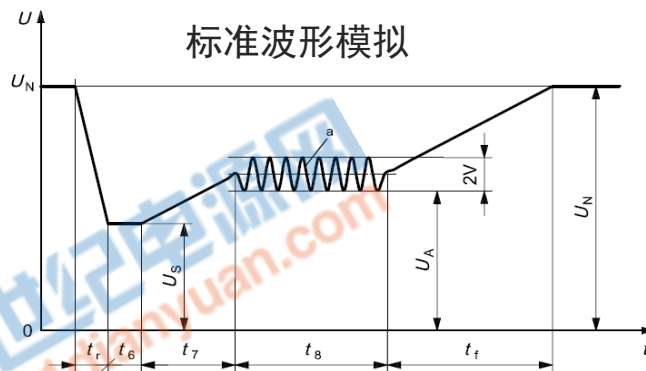
存在问题

- 发动机启动瞬间造成的电压瞬变波形，即汽车每次启动时，都会给车载电子产品这样的电压扰动。
- 工程师必须验证其设计的车载产品是否能够承受这样的电压扰动，不出现重启、死机等现象

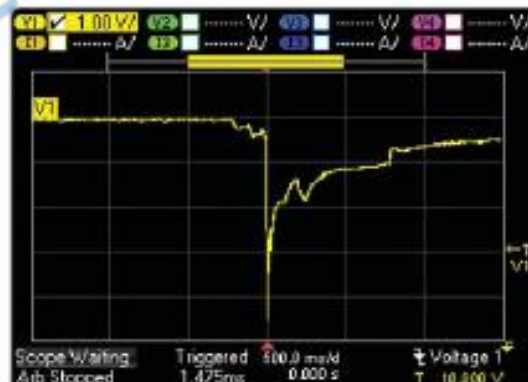


某款汽车发动机启动时的真实波形

模拟场景



- A、蓄电池供电
- B、发动机启动过程
- C、发动机稳定供电

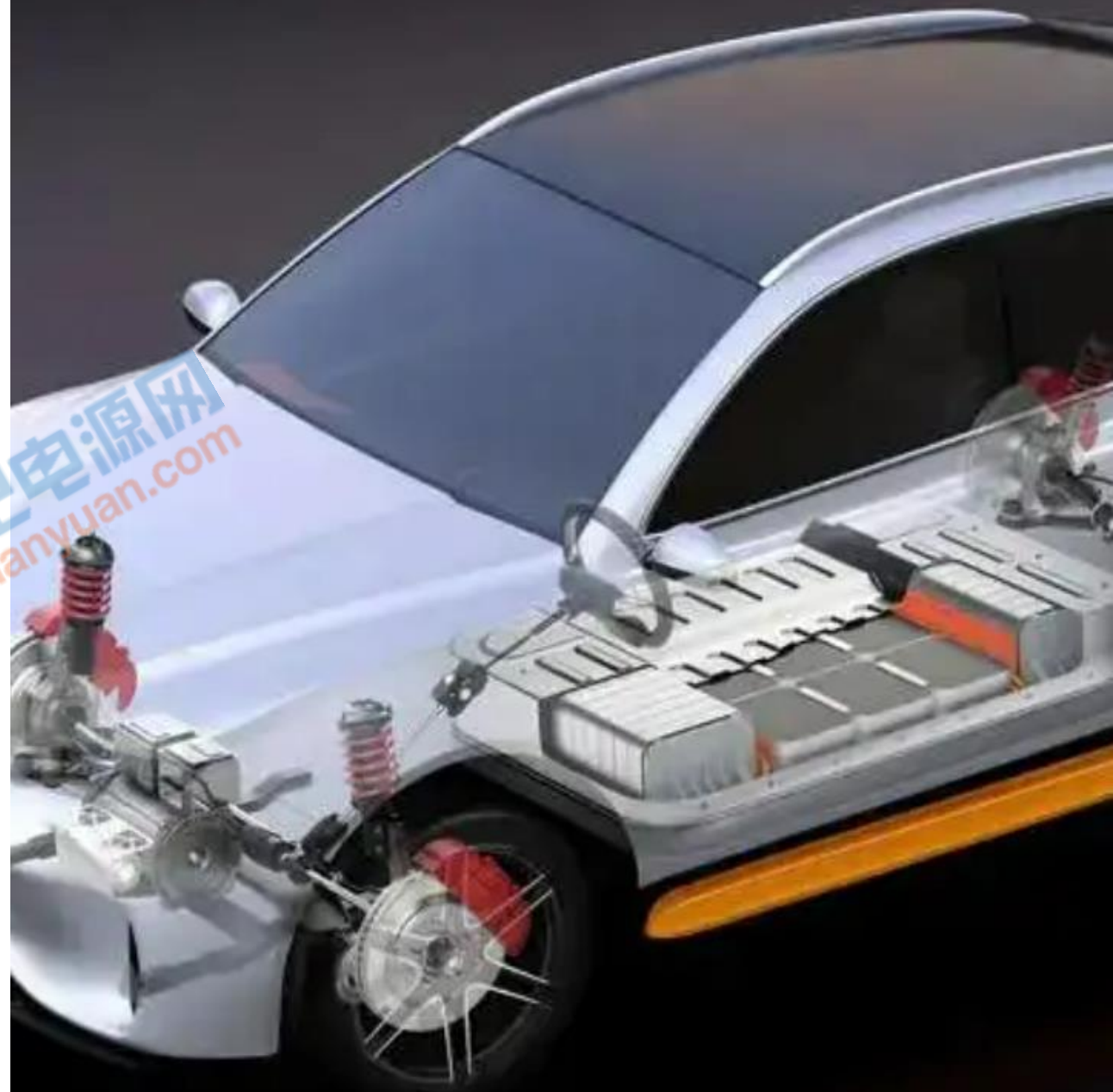


真实的波形复现的模拟

内容

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- 演示

21世纪电源网
21dianyuan.com



供电环境瞬态模拟的实现方式#1

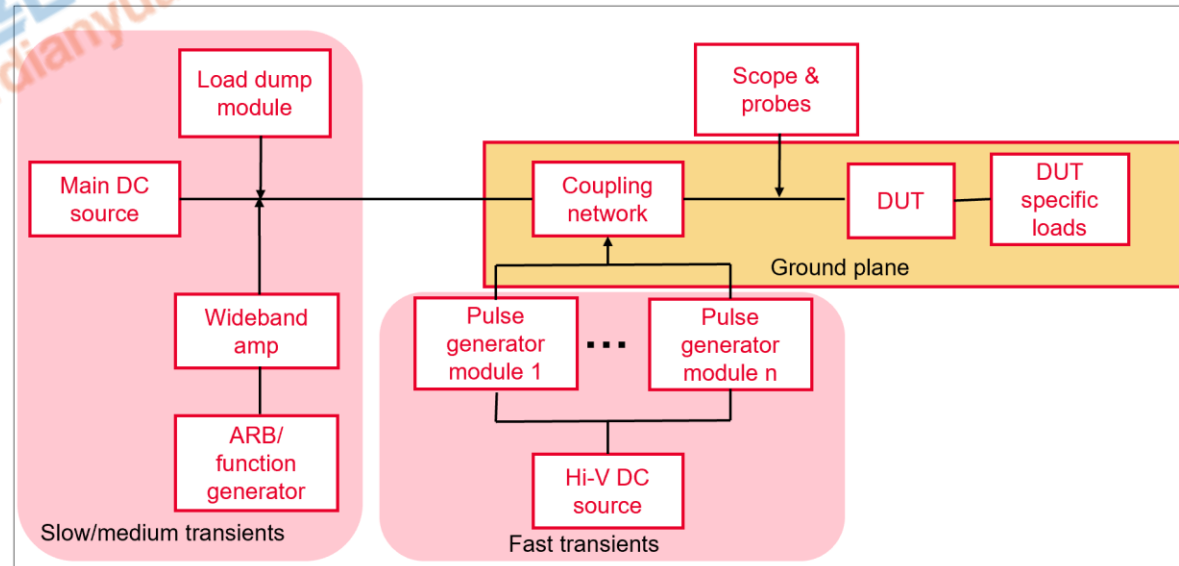
专用的测试系统

优势:

- 内置各种标准波形，适用于标准兼容性的测试
- 操作方便，一键式操作

劣势

- 高成本：绝大部分费用为标准、技术、服务，硬件成本占比很低；
- 扩展性、灵活性差：系统硬件，软件都是定制化，功能单一，只针对当前项目和测试定义；新测试功能或新的项目需要更换不同系统；
- 无法适应研发过程中测试多元化和深层分析的要求
- 选择少：高行业垄断，无法形成竞争优势



供电环境瞬态模拟的实现方式#2

高性能、多功能的先进电源系统



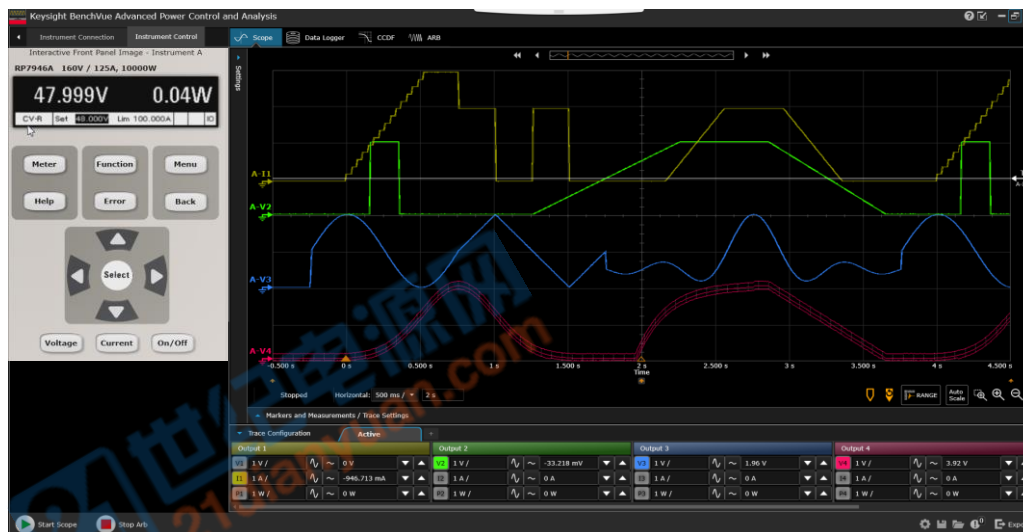
N6705/N6700C 模块化平台
4通道、0-150V, 500W



N7900 APS, 0-160V, 1-2KW



RP7900 APS, 0-2KW, 5-30KW



BV9200 APS分析软件

- ✓ 同时控制4台 N6705 /N7900 /RP7900
- ✓ 4种操作模式：任意波，示波器和数据记录仪
 1. Scope示波器模式，200KSa/s，18比特，精确捕获短时间电压和电流的瞬态变化。
 2. Data Logger记录仪模式，长达1000小时连续数据直接保存到PC。
 3. 64K 点复杂任意波形编辑，支持内置标准波形，公式，波形导入等。
- ✓ 支持API函数调用，用户可进行软件二次开发。

供电环境瞬态模拟的实现方式

两种方式的合理搭配

➤ 灵活性好

可满足不同的供电和测试项目

➤ 低成本

很多部门、工程师日常使用

➤ 分析能力强

产品性能的验证和优化，需要丰富的数据。

➤ 单一性

针对特定的标准和功能

➤ 资质

系统本身需要通过行业协会认证，出具P/F报告

➤ 成本高

硬件占比较低、软件和服务占比高

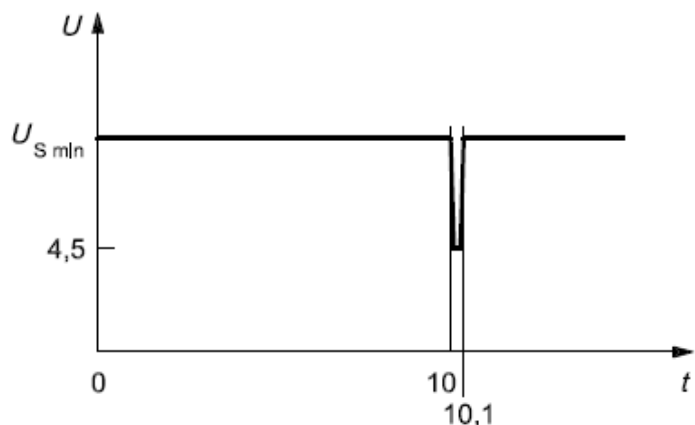
RD研发部门和QA品质部门

认证和质检测试



利用先进电源系统模拟供电瞬变的要素#1

快速的电压调节、较低的电压过冲和前冲



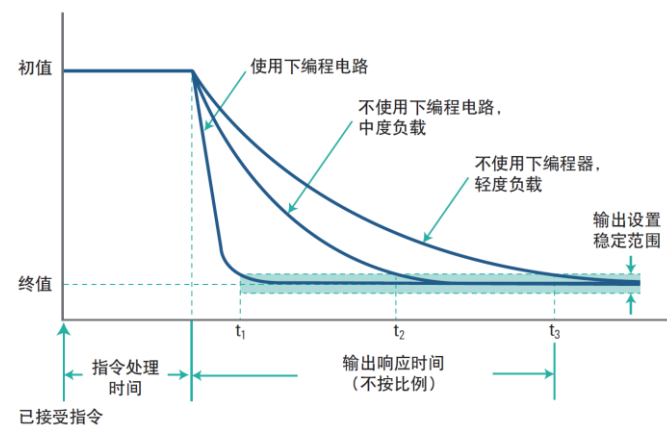
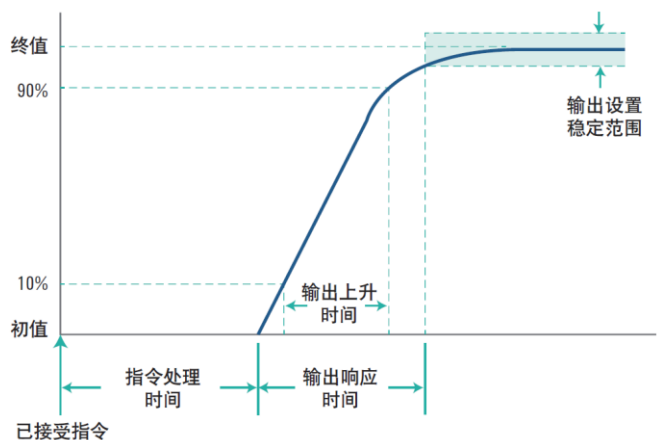
电源模块型号	电压范围	功率	电压上/下编程时间
N6756A	60 V	500W	2.0ms
N7977A	160V	2KW	0.5ms
RP7983A	2000V	30KW	0.2ms

如车用ISO16750瞬间短路波形

1. 电压调节速度很快，理想的跌落；
2. 速度勉强够，低落幅度达到，波形为三角波；
3. 电压调节速度不够，幅度和波形均达不到要求。

利用先进电源系统模拟供电瞬变的要素#1

高压瞬态的模拟



Specification	RP7972A	RP7973A
Output ratings		
Voltage source:	0 to 1000 V	0 to 2000V
Current:	0 to ±60 A	0 to ±30 A
Power:	20 kW	20 kW
Sink Capability:	20 kW	20 kW
Voltage programming & measurement accuracy³	400 ppm + 75 mV	400 ppm + 150 mV
Current programming & measurement accuracy³	300 ppm + 4 mA	300 ppm + 2 mA
Programming Speed⁴		
Voltage rise/fall time with no load:	200 μs	200 μs
Current rise/fall time:	100 μs	100 μs

利用先进电源系统模拟供电瞬变的要素#2

方便快速的波形编辑

1. 内置标准波形和LIST

正弦波, 三角波, 方波, 扫频, 噪声, 指数等

2. 波形序列

可将不同的波形 按照序列组合出复杂序列

3. 导入波形文件支持

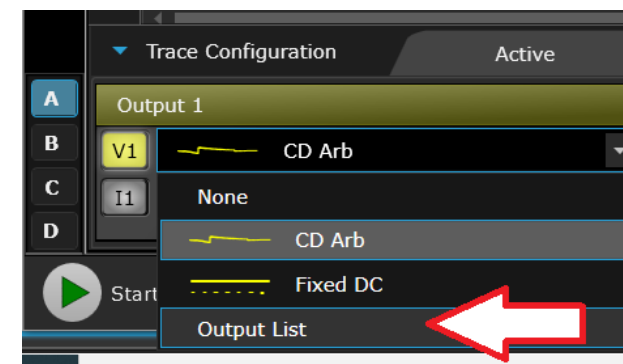
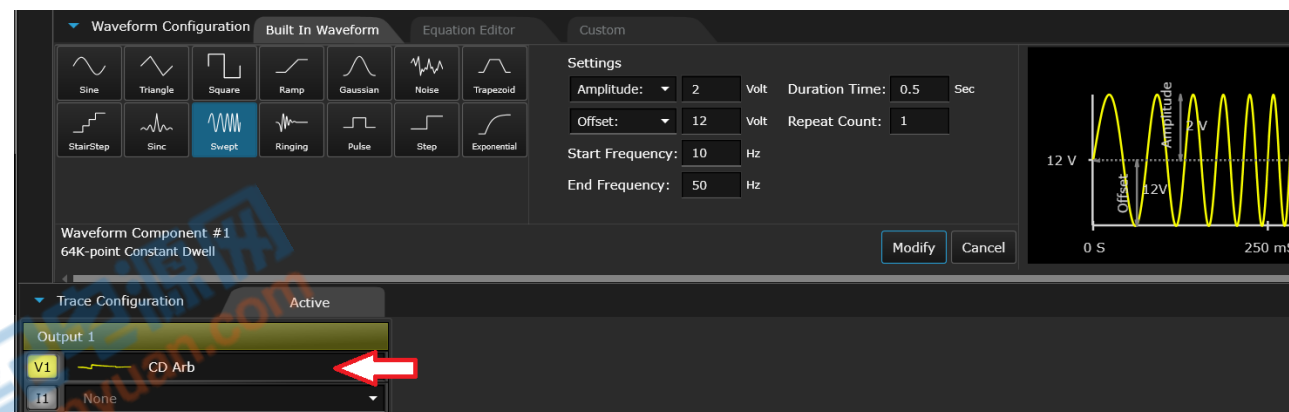
可用示波器/记录仪功能捕捉波形, 再通过

BV9200导入波形文件, 进行波形回放

4. 内嵌公式

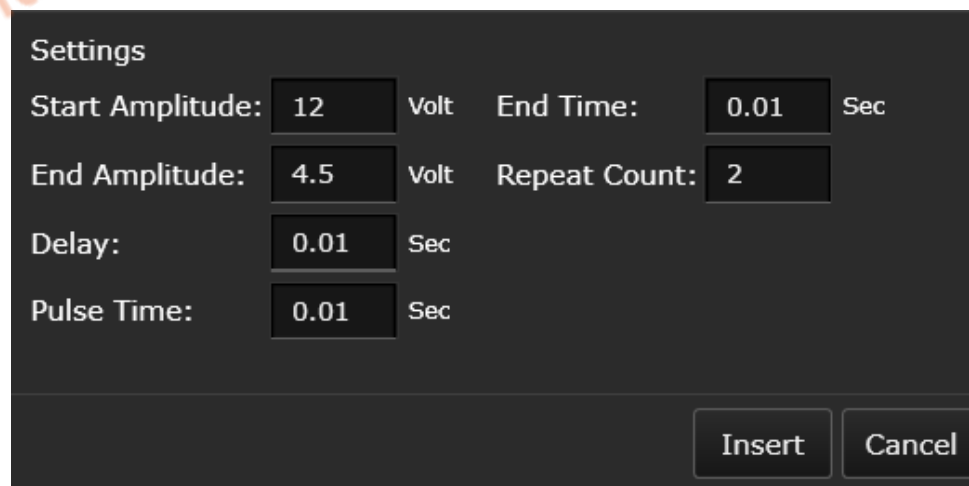
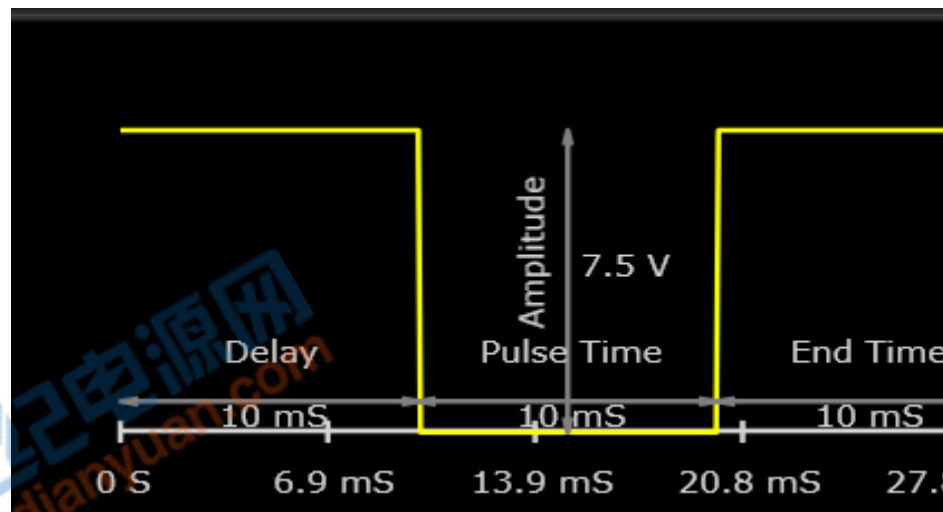
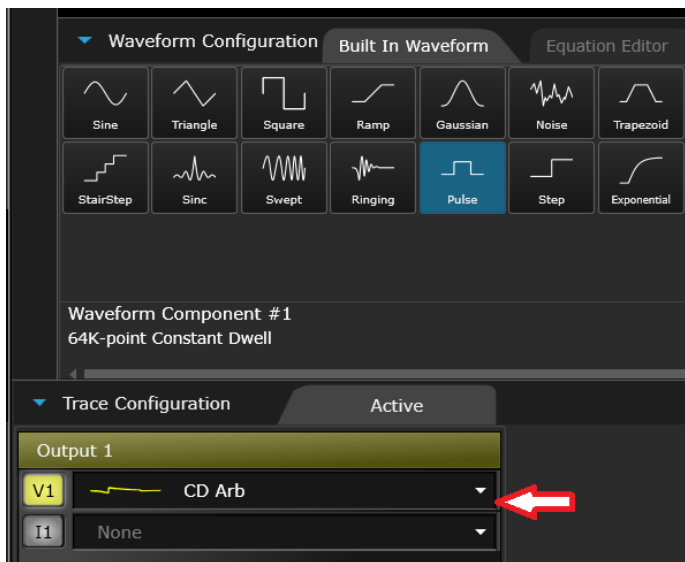
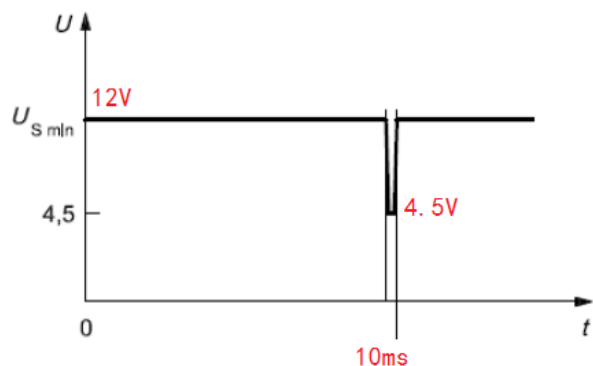
实现更复杂的波形, 如16750抛负载波形

BV9200 ARB 界面



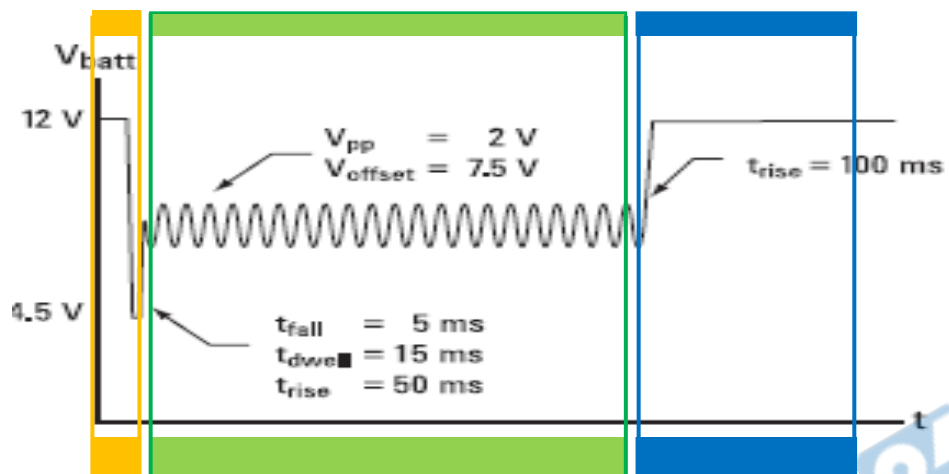
方便快速的波形编辑

内置标准波形

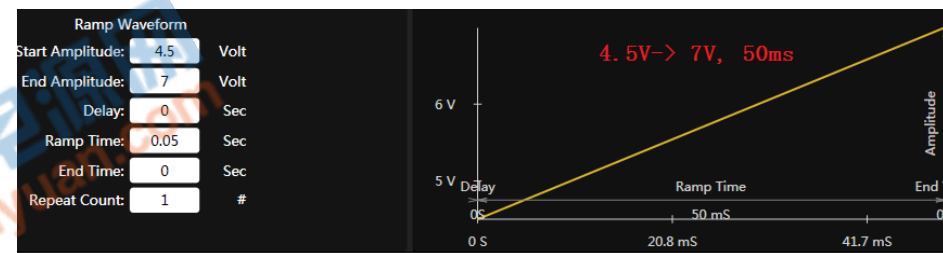
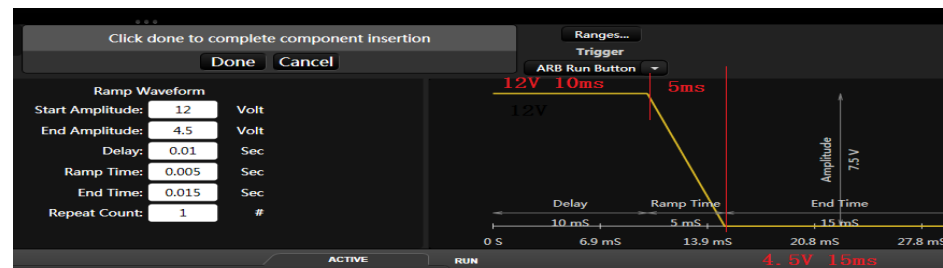
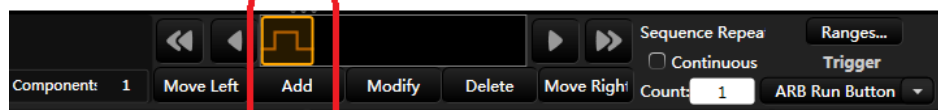


方便快速的波形编辑

内置标准波形+序列

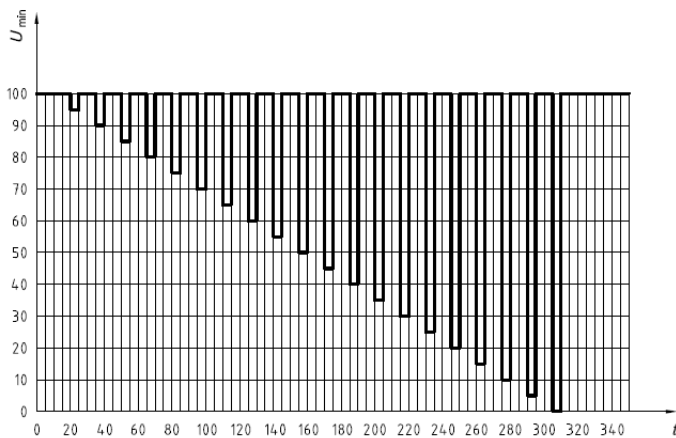


- 将复杂的波形分解成多个简单波形：脉冲，正弦波，三角波等
- 多个基本波形经过拼接后，可以生成所需要的电压
顺便波形模板



方便快速的波形编辑

LIST列表



Excel spreadsheet showing the data for the waveform. The spreadsheet has columns labeled A through G. The data is as follows:

Output List Waveform	TIME	BOST	EOST			
VOLTAGE						
12	3	0	0			
11	1	0	0			
12	3	0	0			
10	1	0	0			
12	3	0	0			
9	1	0	0			
12	3	0	0			
8	1	0	0			
12	3	0	0			
7	1	0	0			
12	3	0	0			
12	3	0	0			
6	1	0	0			

Output List Transient

Construct waveform by steps: (Support up to 512 steps)

Step	Voltage (V)	Time (s)	BOST	EOST
0	12.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
1	11.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
2	12.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
3	10.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
4	12.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
5	9.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
6	12.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
7	8.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
8	12.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>
9	7.0000	1.0000	<input type="checkbox"/>	<input type="checkbox"/>

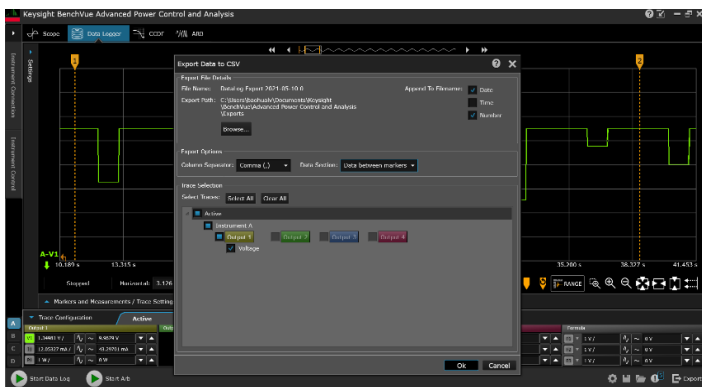
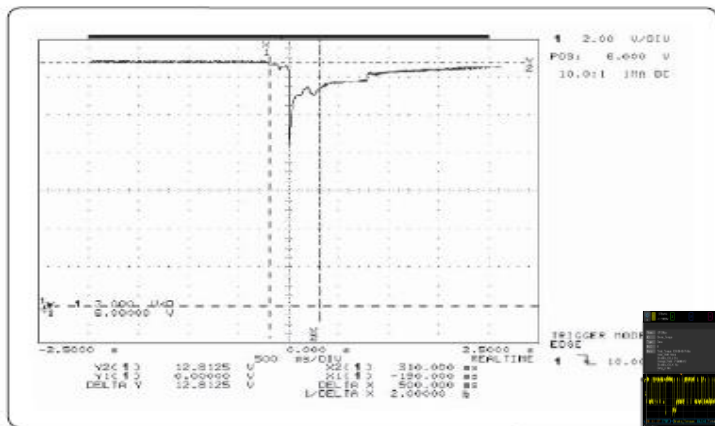
Add New Step

Preview: BOST EOST Both

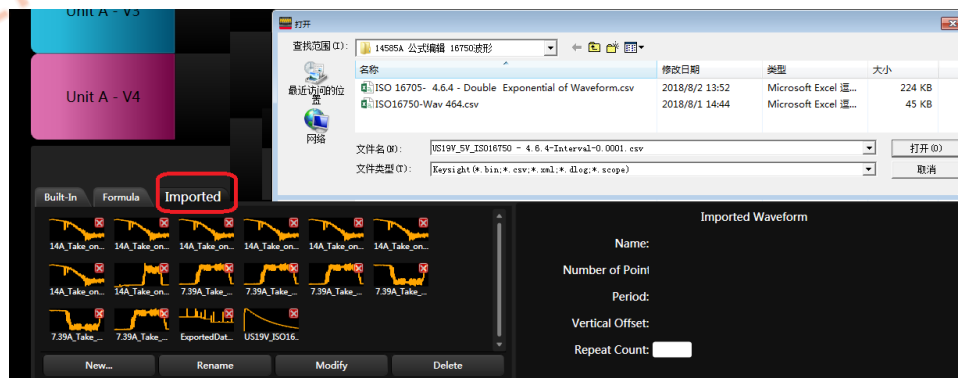
方便快捷的波形编辑

波形导出和波形导入

还原现场偶发 便于故障分析、定位和调试



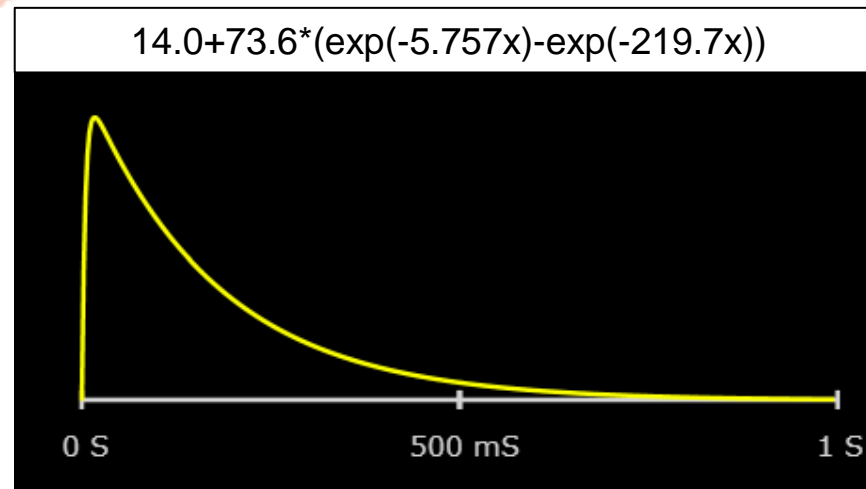
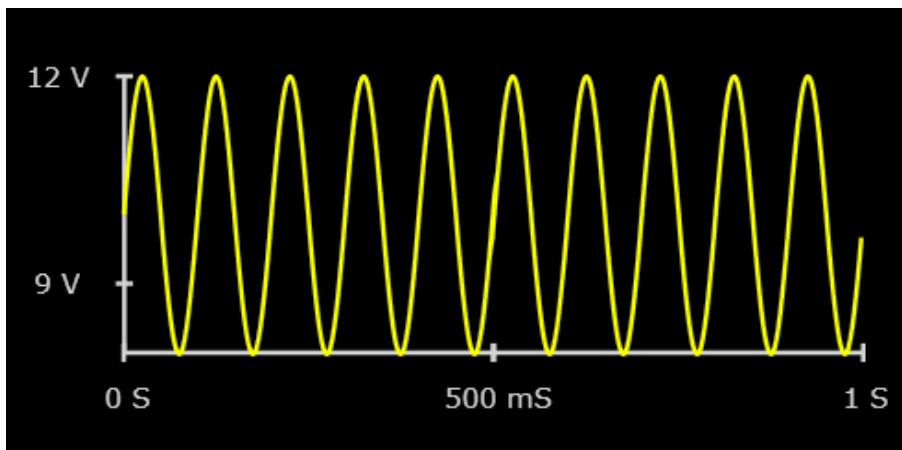
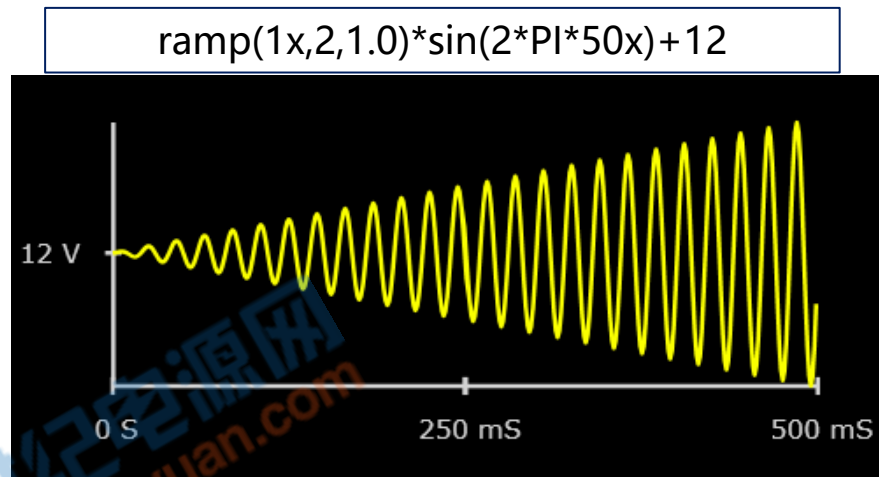
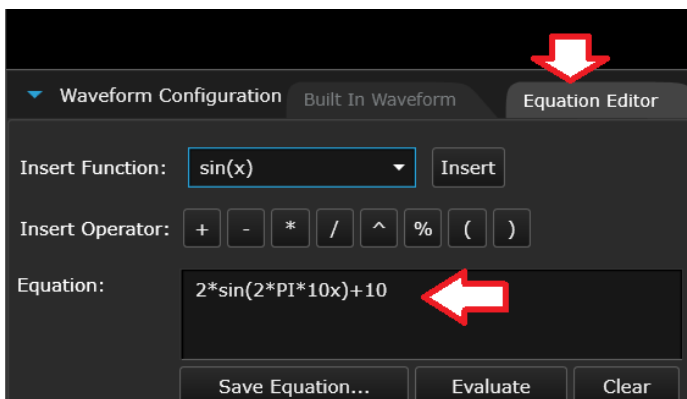
示波器或记录仪波形保存至文件



ARB导入波形文件，复现偶发现象

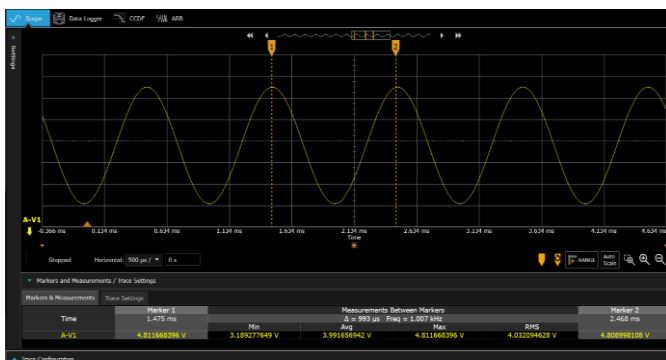
方便快速的波形编辑

函数和公式

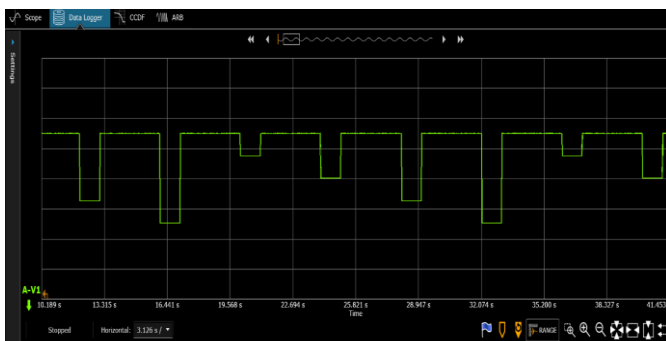


利用先进电源系统模拟供电瞬变的要素 #3

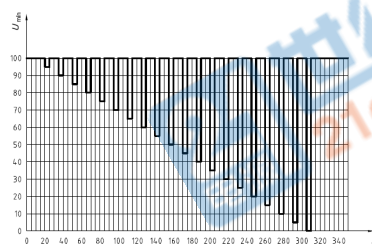
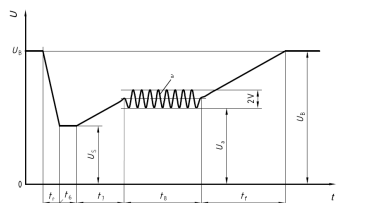
内置的测量和强大的分析能力



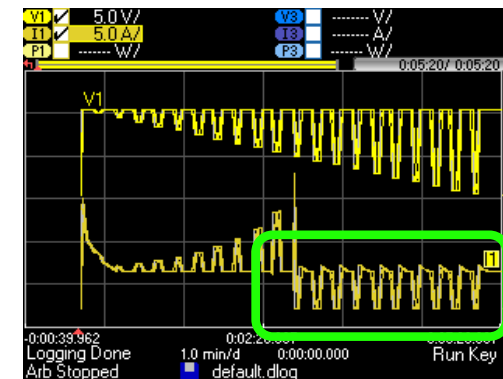
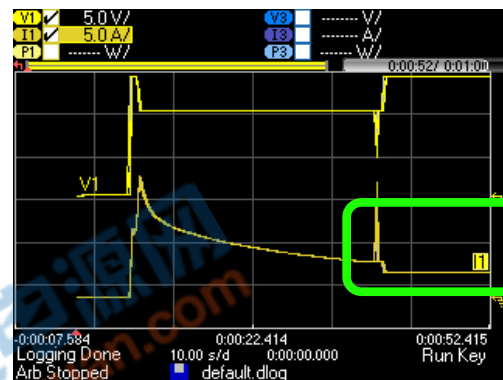
200Ksa/S, 18bit的示波器



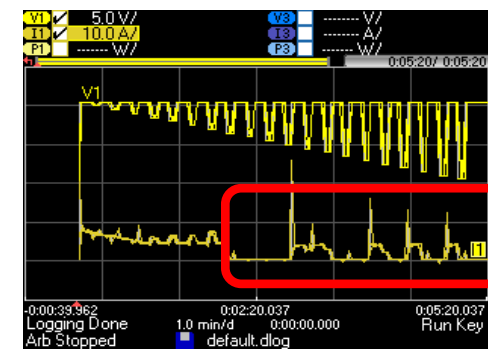
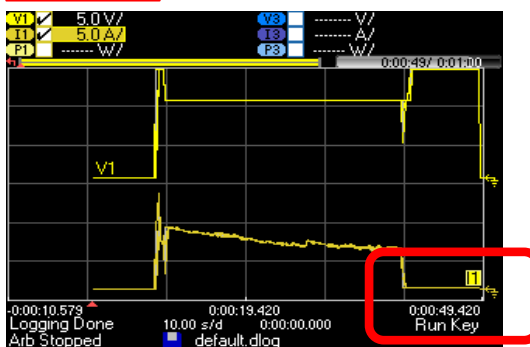
1000hr的数据记录仪



样品A



样品B



利用先进电源系统模拟供电瞬变的要素 #4

道路千万条，安全第一条

- 过压保护，过流保护，过温保护、欠压保护、电源区间保护
- 快速的过压保护启动时间 30-50us
- 过压保护启动后，可以关闭输出，或者降低电压到安全值
- 内置输出继电器，隔离电源与被供电设备
- Watchdog Timer，防止上位机死机造成供电故障
- 远端检测线连接报警
- 远端禁止功能
- 多路电源,可以在发现异常时，多路供电联动关断顺序及延时
- 前面板按键锁定
- 唤醒状态(初始电源状态设定,断电后重启状态恢复)



RP8900 过压保护响应时间

Overvoltage protection		
Maximum setting:	1200V	2400V
Accuracy:	0.02% + 75 mV	0.02% + 150 mV
Response time: ²	< 30 μ s	< 30 μ s



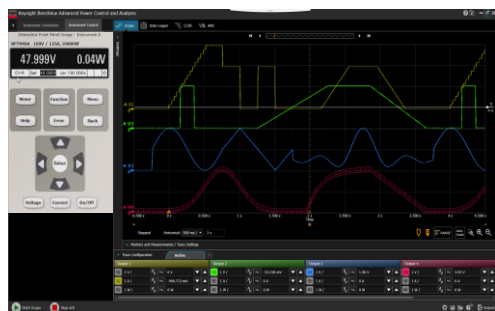
高压瞬态模拟方案

APS 先进电源系统

- 20KW-600KW 功率范围，最高电压2000V
- 多种任意波形编辑，满足但又 **不局限于** 标准
- 内置示波器和数据记录仪，快速定位和分析问题



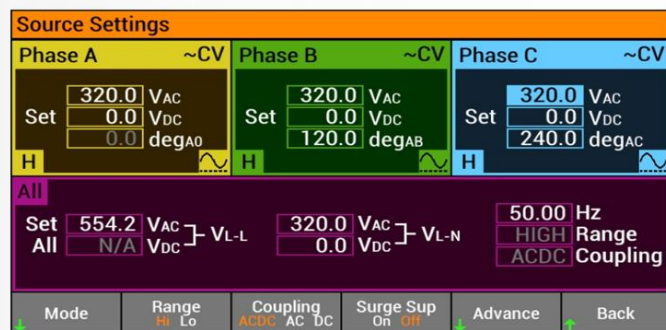
RP7900 APS



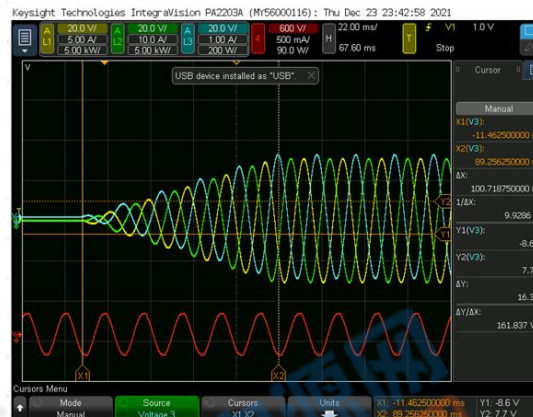
BV9200 APS分析软件

电压	型号	电流	功率
9V	N7950A	±100A	1KW
	N7970A	±200A	2KW
20V	N7951A	±50A	1KW
	N7971A	±100A	2KW
	RP7941A	±400A	5KW
	RP7943A	±800A	10KW
40V	N7952A	±25A	1KW
	N7972A	±50A	2KW
60V	N7953A	±16.7A	1KW
	N7973A	±33A	2KW
80V	N7954A	±12.5A	1KW
	N7974A	±25A	2KW
	RP7942A	±125A	5KW
	RP7945A	±250A	10KW
120V	N7976A	±16.7A	2KW
160V	N7977A	±12.5A	2KW
	RP7946A	±125A	10KW
500V	RP7961A	±20A	5KW
950V	RP7962A	±40A	10KW
1000V	RP7963A	±20A	10KW
1000V	RP7972A	±60A	20KW
1000V	RP7982A	±90A	30KW
2000V	RP7973A	±30A	20KW
2000V	RP7983A	±30A	30KW

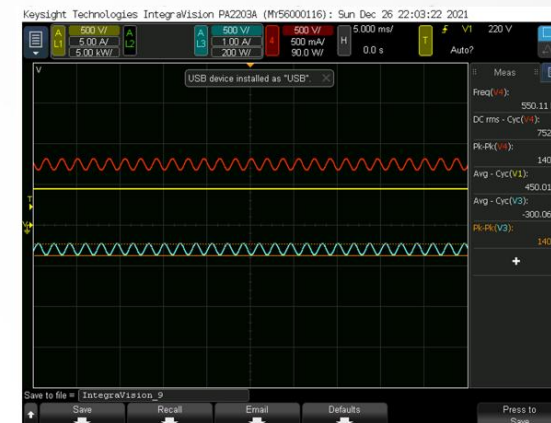
新型AC6900 三相、单相、直流电源



型号	AC6918L/H	AC6912L/H	AC6906L/H	AC6903L/H
AC 功率	18KVA	12KVA	6KVA	3KVA
高度	12U	9U	6U	3U
AC电压量程	160V/320V			
DC电压量程	±226V/452V			
AC 单相最大电流	180/90A	120/60A	60/30A	30/15A
AC 三相最大电流	60/30A	40/20A	20/10A	10/5A
DC 最大电流	180/90A	120/60A	60/30A	30/15A
DC 功率	18KW	12KW	6KW	3KW
频率范围	DC, 1至5000Hz (L型号550Hz)			
AC 电压测量精度	0.03% +100mV (45-100Hz)			
DC 电压测量精度	0.05% + 150mV			
RMS 电流测量精度	0.15% + 0.2% FS (45-65Hz)			
输入电压类型	3相			单相
输入电压范围	380-480V			100-120V 或 200-240V
PF功率因素	>0.95			
输入视在功率	<23.4KVA	<15.6KV	<7.7KV	<4KV
程控接口	USB/LAN, GPIB 可选			
谐波测量	5-50次谐波 (基波频率 10-1000Hz)			
电网模拟	五段式参数定义			
序列编辑和输出	AC、DC, 突变, 斜率控制等			
并联扩展功能和数量	1-4台			无



三相&软启动



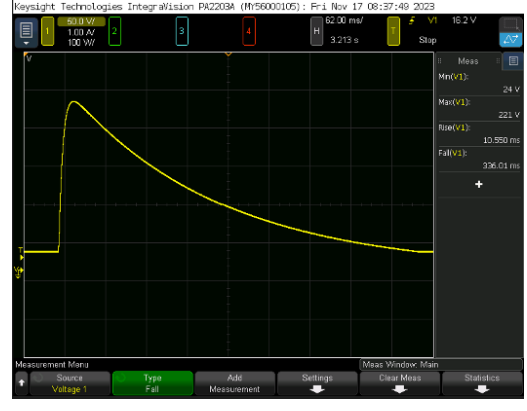
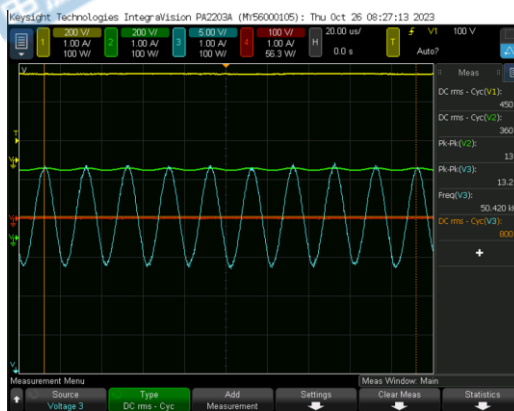
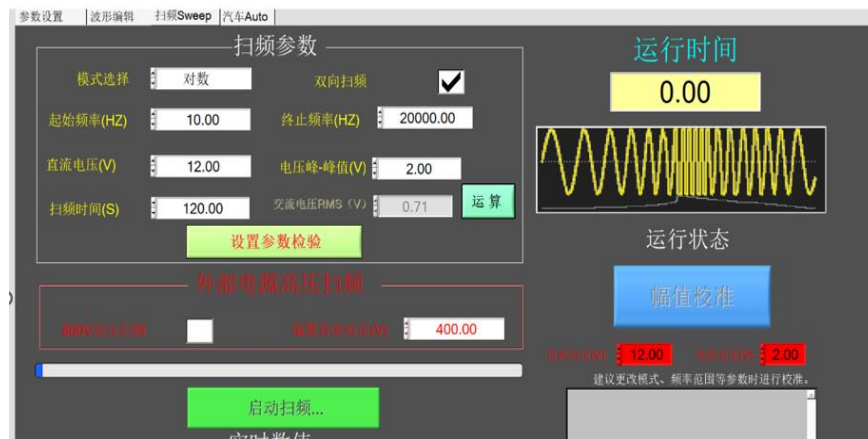
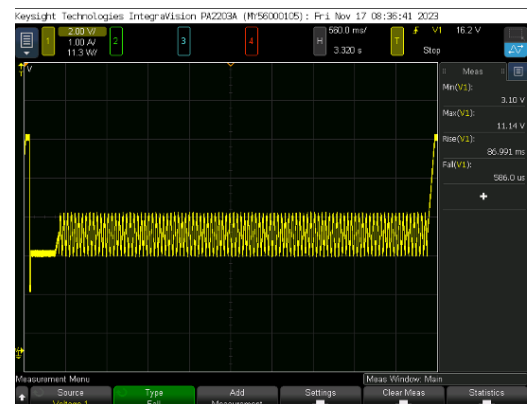
750V直流 + 140VAC/550Hz



单相&输入/输出同相位



AC6900汽车电子跌落、启动、扫频波形



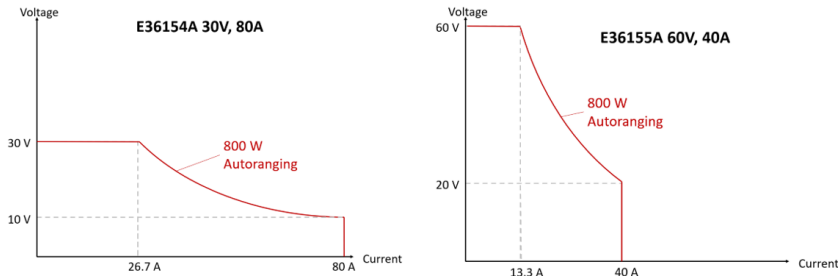
E36150 800W台式电源

汽车电子波形(-选件ATMU), 适用于ISO16750, ISO7637, DIN 40839 部分波形



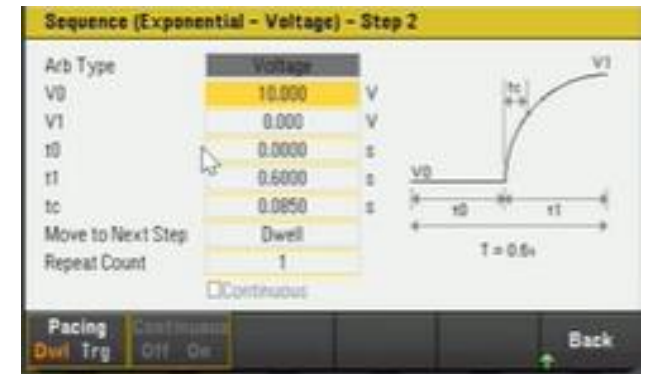
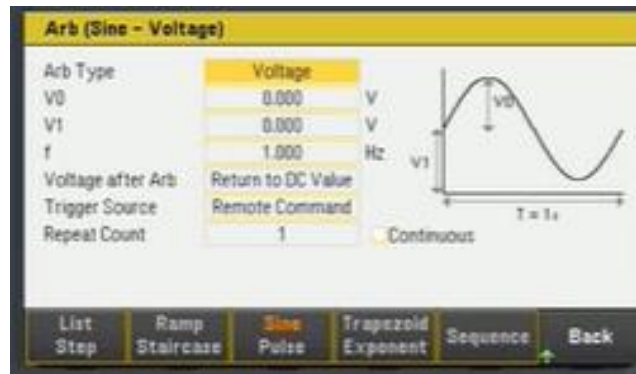
电压上升和下降时间

	无升级	升级选件
满载上升	< 30 ms	1.5 ms
空载上升	< 30 ms	1.5 ms
满载下降	< 30 ms	2.5 ms
空载下降	< 30 ms	4.5 ms



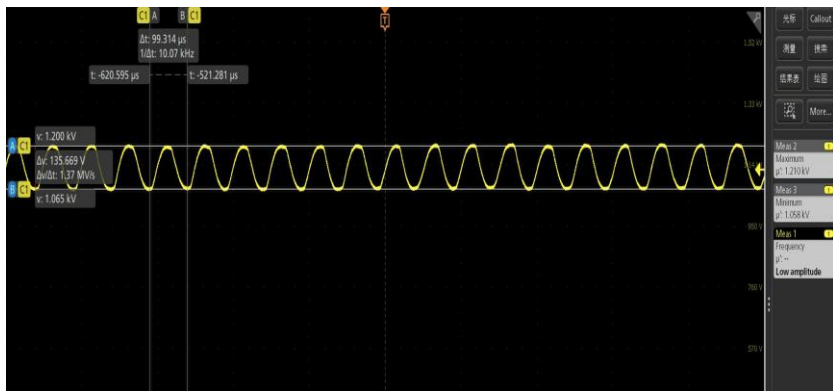
E36150 系列主要技术指标

额定功率	800W
峰值功率	2400W
输出电压	30V/60V
输出电流	80A/40A



应用案例

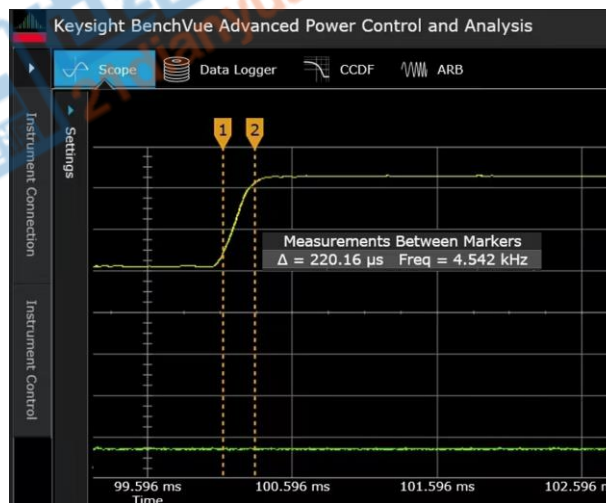
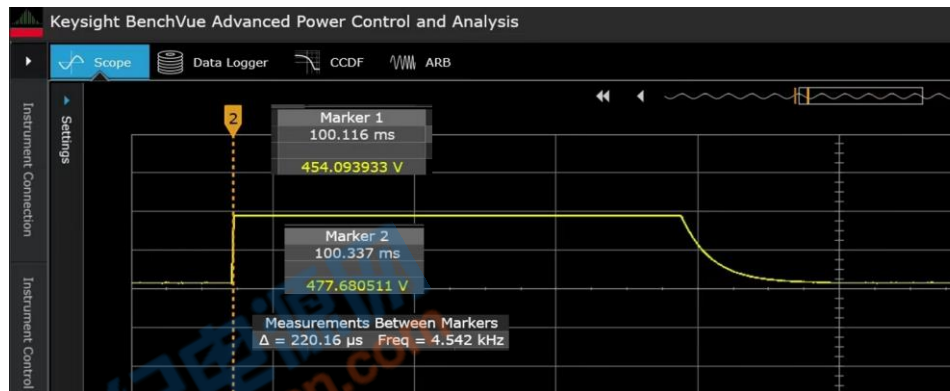
1000V+高压电动汽车的供电环境适应性测试波形



1200Vdc + 10kHz, 135Vp Wave

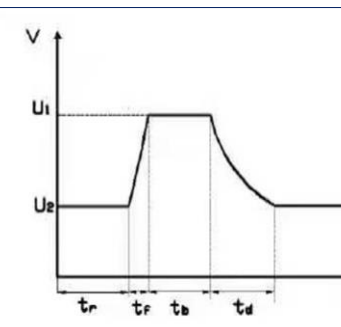


RP7983A ,2000V ,30KW



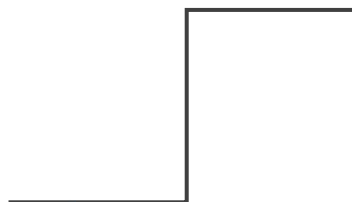
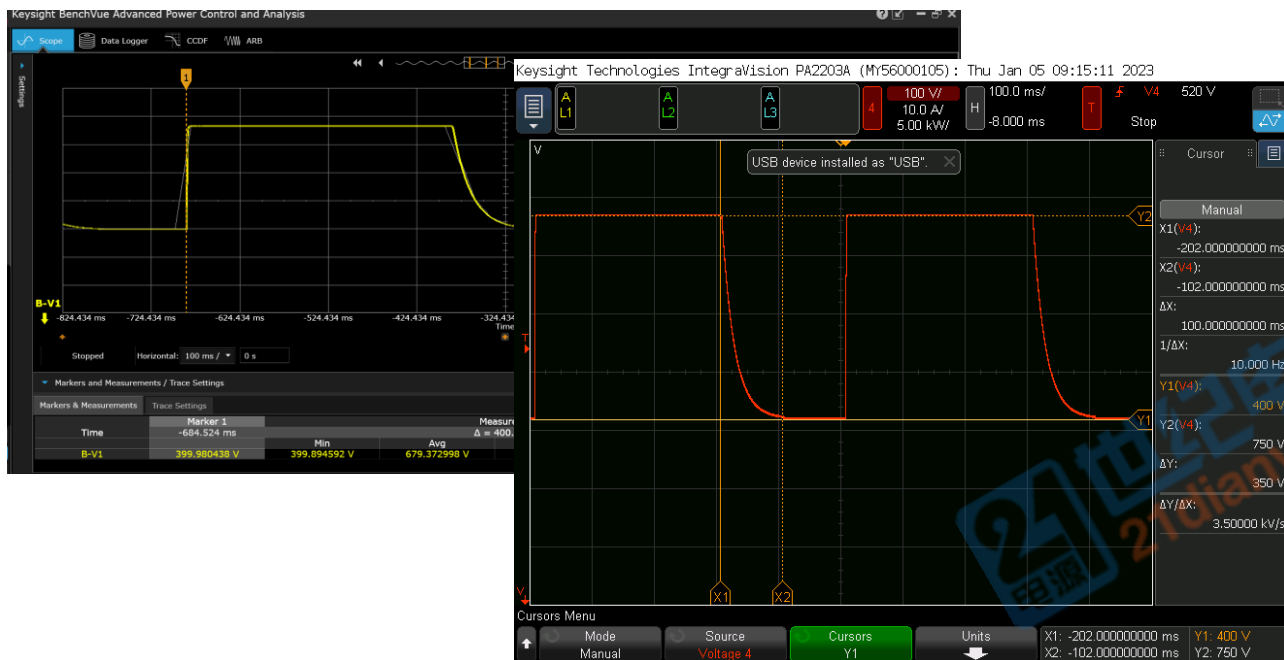
RP7983A/BV9200软件编辑和实测波形

电压参数	U1	Uload,dump
	U2	Umax
时间参数	tr	1 min
	tf	250 V/ms
	tb	300 ms
	td	100 ms
循环次数	进行3次脉冲, 每次间隔2 min	
试验前工作时间	5 min	
工作模式	3.2	



电动汽车 抛负载波形

抛负载的模拟



Settings

Start Amplitude: Volt

End Amplitude: Volt

Delay: Sec

End Time: Sec

Settings

Start Amplitude: Volt

End Amplitude: Volt

Delay: Sec

Raise Time: Sec

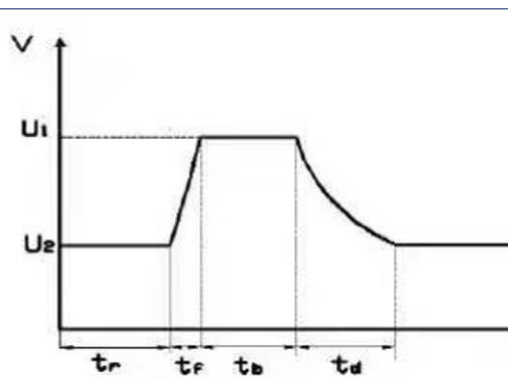
Time Constant: Sec

Repeat Count:

400V – 750V
 $T_b = 300\text{ms}$
 $T_d = 100\text{mS}$

电动汽车 抛负载波形

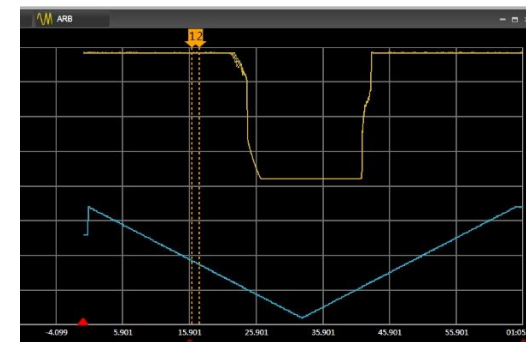
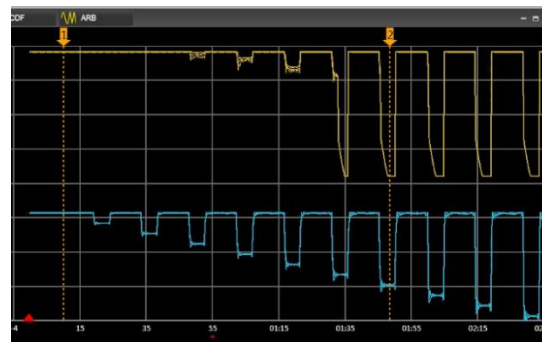
电压参数	U1	Uload, dump
	U2	Umax
时间参数	t_r	1 min
	t_f	250 V/ms
	t_b	300 ms
	t_d	100 ms
循环次数	进行3次脉冲, 每次间隔2 min	
试验前工作时间	5 min	
工作模式	3.2	



应用案例

低压车载导航系统通道环境适应性测试

模拟真实供电环境，找出问题的根源，避开供应商问题上扯皮



内容

- 汽车供电环境适应性要求
- 供电环境适应兼容性测试和真实状态
- 供电环境瞬态模拟的方案构建
- 演示

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