



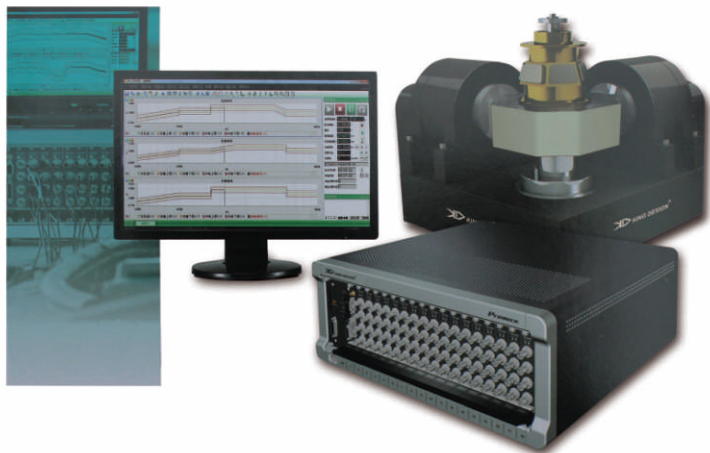
多输入多输出振动控制器

MIMO VIBRATION CONTROLLER

www.king-design.com.cn

金顿科技股份有限公司
金顿仪器科技(昆山)有限公司

MIMO 多输入多输出振动控制器 VIBRATION CONTROLLER



多输入多输出 (MIMO) 振动控制器主要应用于航空航天、土木建筑、机械工程、车辆工程、科学研究等领域, 特别适用于结构较大产品 (或系统) 的振动环境模拟试验, 如验证火箭、导弹、航天飞行器部件、运输车辆及土木建筑等产品或系统的振动可靠性及抗震性能。

随着产品结构复杂化、体积大型化及重型化, 单台激励振动试验因不能提供足够的推力, 或是不能更真实地模拟产品在实际工作过程中所承受的多维振动环境, 而不能达到规定的试验要求。

多输入多输出 (MIMO) 振动控制器, 基于PXI总线结构, 采用多DSP并行处理技术和分布式模块化设计, 实现多输入多输出、多激励单轴、多激励多轴等多种方式的振动控制。通过研究多台同步/异步和多轴向振动控制理论与技术, 研发了矩阵解耦、对角优先矩阵补偿、偏相干技术、复数外差法等高效优质的算法, 并结合10多年积累的闭环检查、系统辨识及自适应控制等多项先进技术, 实现了MIMO正弦、随机、典型冲击、瞬态冲击 (地震波模拟) 及道路谱模拟等振动控制技术。MIMO振动控制器适用于电动/液压振动台的控制, 您可按需求选用输出驱动模块、输入采集模块, 实现多达16个驱动通道、最多64个输入通道。完善的控制及辅助功能, 将助您顺利完成多输入多输出振动试验。

MIMO vibration controller is mainly applied in aerospace industry, civil construction, mechanical engineering, vehicle engineering and scientific research. Especially vibration simulation testing on larger structure products (system) about reliable vibration and anti-seismic performance, such as rocket, missile, aerospace aircraft component, transport vehicle and civil construction.

With product structure complicated and volume large-scale and heavy duty, single vibration testing can't reach the specified testing requirement, because it can't provide enough force and simulate multi-dimensional vibration environment that product will face in working process.

MIMO Vibration Controller (based on PXI bus structure) adopt multi DSP parallel processing technology and distributed modular design to reach vibration control with MIMO, multi incentive uniaxial and multi incentive multi-axial. Through studying vibration control theory and technology in multi synchronous/asynchronous and multi-axial, develop matrix decoupling, diagonal priority matrix compensation, partial coherence technology and the plural heterodyne method. Combined with more than 10 years accumulation of advanced technology in the closed loop check system, system identification and adaptive control, now we can make MIMO sine, random, typical shock, transient impact (seismic wave simulation) and road spectrum simulation. MIMO Vibration Controller is suitable for electric/hydraulic vibration table. You can choose ODM (output driver module) and IAM (Input acquisition module) based on your demand to reach 16 channels or 64 channels. Perfect control and auxiliary function will do your favor to successfully complete MIMO vibration test.

控制模式 Control Model

多台同步振动控制

Multiple synchronous vibration control

对于体积和/或重量很大的产品（如大型机械、船舶、汽车等）的振动试验，使用单台激励无法满足空间或推力的要求而无法进行试验。这就需要两个振动台或多个振动台并联，进行双台或多台同步振动控制实验。

Vibration testing on large volume and weight product (E.g.: large machinery, ship, automobile), single set can't meet space and force requirement, thus it need double or multi sets together to make vibration testing.



多台异步振动控制

Multiple asynchronous vibration control

对于细长体结构（如火箭、导弹、桥梁等）的振动试验，使用多台单轴异步振动控制，可使试件的振动载荷分布更加均匀、合理真实，减少单台激励带来的应力集中，减轻局部欠试验或过试验程度，同时使夹具设计更加灵活方便。

For the thin and long product (E.g.: rocket, missile, bridge), vibration testing take multiple uniaxial asynchronous vibration control, to make load distribution more uniform and reasonable, reduce the stress concentration caused by single set and fewer test or over test on local, and make fixture design more flexible and convenient.

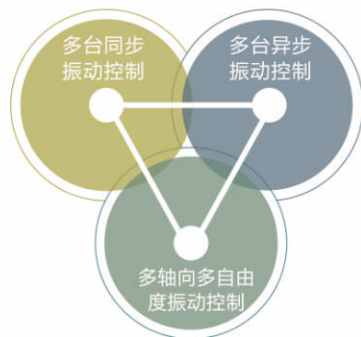
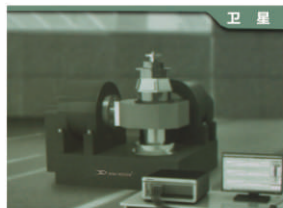


多轴向多自由度振动控制

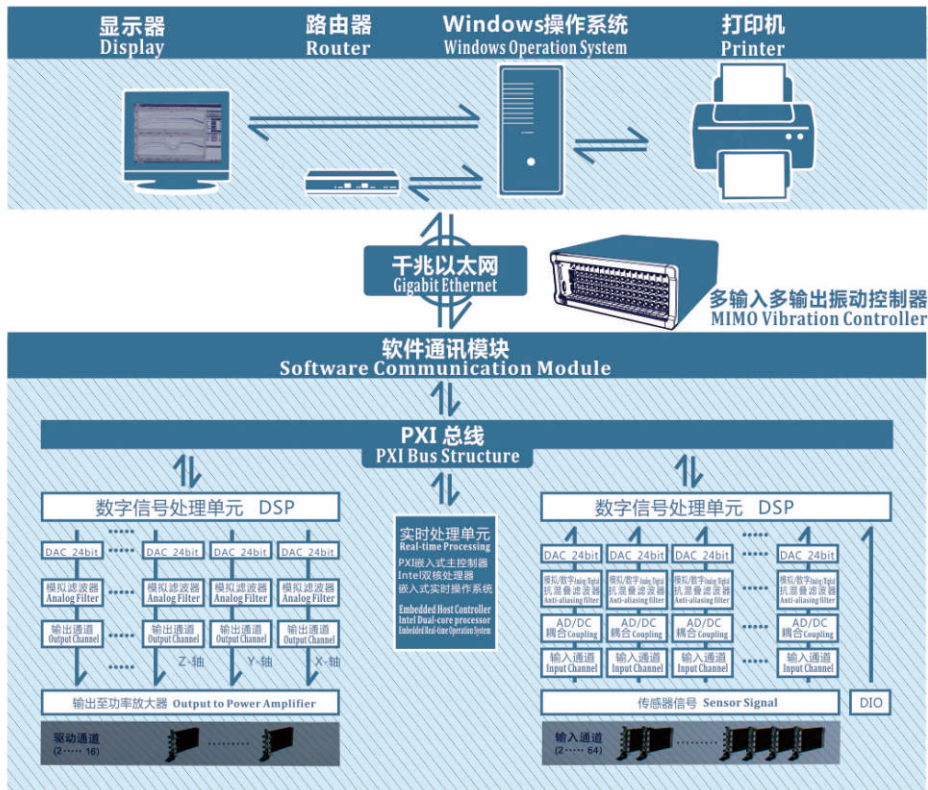
Multi-axial and Multi Degree of Freedom vibration control

对于复杂结构的产品或精密仪器（如人造卫星等），采用单轴振动试验容易造成产品的一部分过试验而另一部分欠试验，且过试验和欠试验的程度难以定量估计，从而影响受试产品可靠性的定量评定。采用多轴向多自由度振动环境试验可以有效避免产品在实验过程中的过试验和欠试验。

For the complex structure product and precision instrument (E.g.: man-made satellite), adopt uniaxial vibration testing easily appear that this part is over test and other part is fewer test, and difficult to quantitative estimation about degree, thus to affect quantitative evaluation of product reliability. With multi-axial and multi degree of freedom vibration control, effectively avoid fewer test and over test during testing period.



◆ 原理图 THEORY DAGRAM ◆

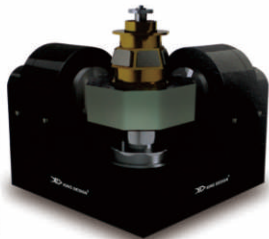
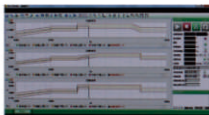


MIMO 正弦振动控制功能

Multiple input Multiple output Vibration Controller

功能概述 Function Overview

MIMO 正弦振动试验主要对诸如旋转机械、直升机旋翼结构等具有正弦性质振动的实际环境进行模拟。不同于单点正弦振动试验控制，MIMO正弦振动试验除了要控制试件上多个控制点本身响应信号幅值满足预设的要求外，还需要对控制点响应信号之间的相位关系进行控制。软件采用自适应矩阵解耦补偿算法，结合相对相位修正技术，对系统的非线性、共振频率以及载荷变化做出快速响应，确保对复杂系统执行实时精确的闭环控制。正弦控制精度典型值，幅值误差±1.0dB，相位误差小于1°。



King Design MIMO sine vibration testing is mainly applied in actual environment where sine vibration happens, E.g.: rotating machinery and helicopter rotor structure. Different from the control of single sine vibration testing, MIMO Sine Vibration testing not only need to control multiple control points on the specimen itself to meet the requirements of the preset signal amplitude, but also control the phase relationship among response signals of control points. Combined with the relative phase correction technology, software adopt adaptive matrix decoupling compensation algorithm to make quick response to non-linear system, resonant frequency and load change, to make sure accurate closed-loop control of complex system.

Sine controls typical accurate value.

Amplitude Error: $\pm 1.0\text{dB}$ Phase Error $< 1^\circ$

软件功能概述 Software Functions

- | | |
|--------------------------|---|
| 1. 控制动态范围：大于90dB； | 1. Dynamic Range: $> 90\text{dB}$ |
| 2. 闭环时间：10ms，不受输出通道数的影响； | 2. closed-loop time: 10ms (won't affect by number of output channels) |
| 3. 谐波失真：小于-100dB； | 3. THD: $< -100\text{dB}$ |
| 4. 频率范围: 1Hz~5000 Hz; | 4. Frequency Range: 1Hz~5000 Hz |
| 5. 分析谱线：512~4096可选； | 5. Analytical Spectral Line: 512~4096 |
| 6. 相位：-180度~180度； | 6. Phase: -180~180 |
| 7. 阻抗矩阵：可辨识或导入； | 7. Impedance matrix: identifiable or import |
| 8. 高级选项：长方阵控制、多变量控制； | 8. Advanced Option: rectangular matrix control, multivariable control |

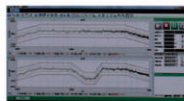
MIMO 随机振动控制功能 MIMO Random Vibration Control Function

功能概述 Function Overview

金顿科技的 MIMO 随机振动控制功能可以实时地对16个单轴振动台实施同步/异步振动控制，实现多自由度的随机振动环境模拟试验，可精确、快速以及安全地再现各类参考目标谱MIMO 随机控制采用对角优先的矩阵补偿算法和阻抗矩阵更新算法相结合的控制策略，对系统的非线性、共振频率以及载荷变化做出迅速响应。采用偏相干技术，准确快速识别多输入多输出系统共振点与反共振点，确保系统控制的稳定性和可靠性。随机控制精度典型值，幅值误差 $\pm 1.0\text{dB}$ ，相位误差小于 2° ，相干误差小于 ± 0.1 。

King Design MIMO random vibration control function can control real-time synchronous/asynchronous vibration of 16 uniaxial vibration tables, realize multiple degree random vibration environment simulation. And accurately, quickly and safely recreate various reference target spectrum. MIMO random control connect focus priority matrix compensation algorithm with Impedance matrix updating algorithm to make quick response to non-linear system, resonant frequency and load change. With partial coherence technology, we can accurately and quickly identify MIMO system resonance point and anti-resonance point to ensure the stability and reliability of system control. Random control typical accurate value.

Amplitude Error: $\pm 1.0\text{dB}$ Phase Error $< 2^\circ$ Coherence Error: ± 0.1



软件功能概述 Software Functions

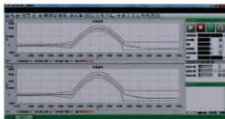
- | | |
|-----------------------|---|
| 1. 控制动态范围：大于90dB； | 1. Dynamic Range: $> 90\text{dB}$ |
| 2. 频率范围: 1Hz~4680 Hz; | 2. Frequency Range: 1Hz~5000 Hz |
| 3. 分析谱线：100~3200可选； | 3. Analytical Spectral Line: 512~4096 |
| 4. 相干系数：0~1； | 4. Coherence Coefficient: 0~1 |
| 5. 相位：-180度~180度； | 5. Phase: -180~180 |
| 6. 阻抗矩阵：可辨识或导入； | 6. Impedance matrix: Identifiable or import |
| 7. 高级选项：长方阵控制、多变量控制； | 7. Advanced Option: rectangular matrix control, multivariable control |

MIMO 典型冲击振动控制功能 Typical Shock and Vibration Control Function

功能概述 Function Overview

传统的冲击试验大多在单个振动台上进行，为了更好地模拟产品所受到的实际冲击环境，使用多输入多输出冲击试验（多振动台）能更真实地在实验室中模拟产品的实际冲击环境，有效地减少试验时间，使产品在试验中的应力分布更趋合理，从而可以有效评估产品的可靠性。金顿科技的MIMO典型冲击控制功能基于交叉耦合补偿、频响矩阵更新、相干平滑的自适应控制，基于矩阵补偿的波形控制，精确快速地补偿系统的非线性与时域变化。

Traditional shock testing is mostly operated on single vibration table. To better simulate actual shock environment that product encountered, use MIMO shock testing (several vibration tables) in the lab, save testing time, make the stress distribution more reasonable, then to effectively evaluate the product reliability. King Design MIMO typical shock control function can accurately and quickly compensate system nonlinear and time domain change, based on cross-coupled compensation, update frequency response matrix, coherent smooth adaptive control and matrix compensation waveform control.



软件功能概述 Software Functions

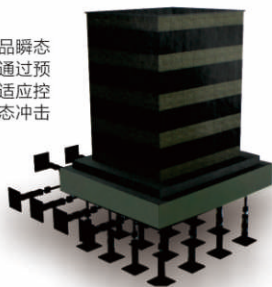
1. 控制动态范围：大于90dB；
 2. 脉冲类型：半正弦波、前峰锯齿波、后峰锯齿波、梯形波、矩形波、钟形波、三角波；
 3. 脉冲宽度：0.5~3,000ms
 4. 容差标准：MIL-STD-810、ISO、用户自定义
 5. 采样频率：20Hz~48kHz,根据脉宽和设置的补偿自动调整；
 6. 帧大小：256~16384，根据脉宽和设置的补偿自动调整；
 7. 阻抗矩阵：可辨识或导入；
 8. 高级选项：长方阵控制、多变量控制；
1. Dynamic Range: > 90dB
 2. Pulse Type: half-sine wave, Forward sawtooth wave, after sawtooth wave, trapezoidal wave, rectangular wave, Bell-shaped wave, and triangular wave
 3. Pulse width: 0.5~3,000ms
 4. Tolerance standard: MIL-STD-810、ISO、user-defined
 5. Sampling Frequency: 20Hz~48 kHz, automatically adjust based on pulse width and compensation setting.
 6. Frame Size: 256~16384, automatically adjust based on pulse width and compensation setting.
 7. Impedance matrix: Identifiable or import
 8. Advanced Option: rectangular matrix control, multivariable control

MIMO 瞬态冲击振动控制功能 MIMO Transient Shock and Vibration Control Function

功能概述 Function Overview

瞬态冲击控制可以在实验室的振动台系统上模拟一些实测的瞬态冲击，如地震、火工品瞬态和其它高频冲击、路面颠簸和跌落冲击等。金顿科技的MIMO瞬态冲击振动控制功能通过预试验辨识系统参数，采用优越的系统解耦算法和基于传递函数和误差修正相结合的自适应控制算法，即使对于有着非线性、强耦合的系统也能获得良好的控制效果，真实再现瞬态冲击振动环境，如再现 Bellcore 标准的地震波等。

Transient shock control can simulate some measured transient shock (E.g.: earthquake, initiating explosive device transient, other high-freq shock, road bump and drop shock) on vibration table in the lab. King Design MIMO transient shock and vibration control



function can identify system parameters by trial test, use superior system decoupling algorithm and adaptive control algorithm based on relaying culvert number and error correction. Even for non-linear, strong coupling system also can get better control, truly recreate transient shock vibration environment (E.g.: BellcoreS Standard Wave).

软件功能概述 Software Functions

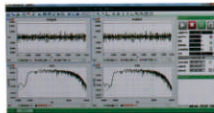
1. 控制动态范围：90Db；
 2. 目标波形：正弦、白噪声、导入实测数据；
 3. 支持导入实测数据的格式：ECON二进制、txt文本、UFF、ECON路谱文件；
 4. 采样频率：20Hz-48kHz,可根据导入波形自动调整；
 5. 帧大小：可达16384；
 6. 阻抗矩阵：可辨识或导入；
 7. 高级选项：长方阵控制、多变量控制；
1. Dynamic Range : 90dB
 2. Waveform: Sine , white noise, Import the measured data
 3. Support for importing measured data format: ECON binary, TXT,UFF,ECON road spectrum file
 4. Sampling Frequency:20Hz-48kHz, Auto adjust according to imported waveform
 5. Frame Size: Up to 16384
 6. Impedance matrix: Identifiable or import
 7. Advanced Option: rectangular matrix control, multivariable

MIMO道路谱模拟振动控制功能 MIMO Road Spectrum Simulation Vibration Control Function

功能概述 Function Overview

道路谱模拟试验是检验车辆部件及整车可靠性的重要方法，但是传统的路试必定会耗费大量的人力、物力和时间。汽车道路谱模拟试验技术的出现，可以实现实验室内模拟汽车在道路行驶中的振动，为汽车路试提供了低成本、高效率的解决方案。金顿科技的MIMO道路谱模拟振动控制功能允许您从测试产品所经历的真实振动环境中采集长时间历程信号作为振动目标谱，在实验室内的振动台上再现产品所受到的振动激励，使模拟复杂的汽车振动环境成为现实。




Road spectrum simulation testing is an important way to examine vehicle component and vehicle reliability. But traditional road testing cost plenty of manpower and material and time. With the appearance of automobile road spectrum simulation testing technology, we can simulate car vibration (driving on the road) in the lab, provide low-cost and high-efficient plan for car testing. King Design MIMO road spectrum vibration control function allow to gather long-time signal as target vibration spectrum, recreate vibration excitation that product encounter on the lab vibration table, make the reality of stimulating complex car vibration environment.



软件功能概述 Software Functions

1. 控制动态范围：90Db；
 2. 数据来源：由路谱波形编辑器生成的路谱文件；
 3. 路谱波形编辑器支持导入的数据格式：txt文本、UFF、CSV、ECON数据格式；
 4. 采样频率：20Hz到48kHz，根据导入信号的采样频率；
 5. 持续时间：从几秒到几十个小时，与采样参数有关；
 6. 阻抗矩阵：可辨识或导入；
 7. 高级选项：长方阵控制、多变量控制；
1. Dynamic Range : 90dB
 2. Data Source: Road spectrum file is generated by road spectrum waveform editor
 3. Road spectrum waveform editor support imported data format: txt, UFF、CSV、ECON data format
 4. Sampling Frequency: 20Hz~48kHz (according to sampling frequency of imported signal)
 5. Duration: several seconds ~ dozens of hours, related to the sampling parameters
 6. Impedance matrix: Identifiable or import
 7. Advanced Option: rectangular matrix control, multivariable control

产品规格 Product Specification

机箱型号 Controller Model	MI-8008	MI-8014	MI-8018
			
插槽数 Interface	8	14	18
输入通道 Input Channel	24	48	64
输出通道 Output Channel		16	
动态范围 Dynamic Range		120dB	
电压范围 Voltage Range	输入范围 ± 10 Vpeak, 输入保护 ± 36 Vpeak		
耦合方式 Coupling Mode	AC差分、AC单端、DC差分、DC单端、ICP、TEDS(可选)		
谐波失真 Total Harmonic Distortion	< -105dB		
通道匹配 Channel Matching	幅值 ± 0.05 dB、相位 $\pm 0.5^\circ$ (DC-21kHz)		
信噪比 Signal to Noise Ratio	> 100dB		
幅值精度 Amplitude Accuracy	0.1dB (1kHz 正弦信号)		

产品性能 Product Performance

MIMO振动控制器主要性能 Main Features of MIMO Vibration Controller

- 可同时控制2-16个振动台
- 单台可多达64个输入通道
- 基于PXI总线和实时操作系统，采用多DSP并行处理技术，控制实时性高
- 通过千兆以太网，实现远程控制
- 随机、正弦、典型冲击、瞬态冲击（地震波模拟）、道路谱模拟5大功能
- 120dB动态范围，随机控制动态范围大于90dB
- 正弦控制频率范围到5000Hz
- control 2-16 vibration table at the same time
- Single set can up to 64 input channels
- Based on PXI bus structure and RTOS(real-time operating system), adopt multi DSP parallel processing technology. High real-time control.
- Realize the remote control through the gigabit Ethernet
- 5 functions: sine, random, typical shock, transient shock (seismic wave simulation) and road spectrum simulation.
- 120dB dynamic range, random dynamic range > 90dB
- Sine frequency range up to 5000Hz

产品优点 Product Merit

MIMO振动控制器优点 Main Advantages of MIMO Vibration Controller

- 自适应矩阵控制
- 正弦试验采用分段辨识技术，辨识精度高
- 基于PXI总线结构，网线连接具有断线重连功能且不丢失数据，可靠性高
- 开环检测、有效值中断、超限谱线、驱动限制、振动台限制、急停按钮等，安全性高
- 软件运行在Windows操作系统，图形化界面，操作简便
- King MIMO控制器不需要任何特殊板卡或驱动软件，使用任何一台电脑，插入网线即可开始试验
- 专业的测试报告可在试验完成后自动生成
- The adaptive control matrix
- Sine testing adopts subsection identification technology, High identification accuracy
- Based on PXI bus structure, Network cable has reconnection function without loss of data, high reliability
- With high security, E.g.: open-loop detection, effective to interrupt, transmute spectral line, drive limit, vibration table limitation, emergency stop button.
- Software running on windows operating system, GUI(Graphical User Interface), Easy to operate
- King Design MIMO Controller don't need any special board card and

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掃描二維碼關注