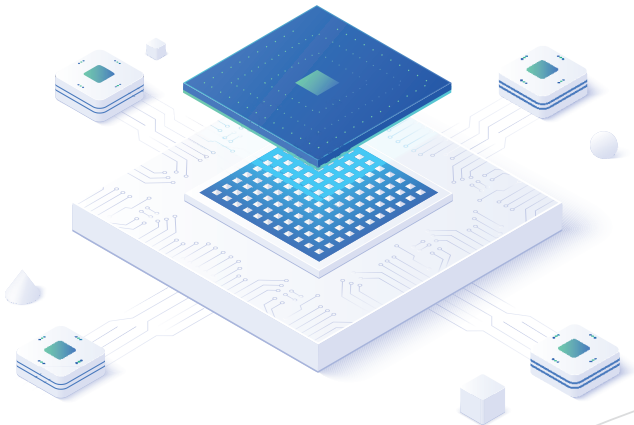
King Son Semiconductor Test Chambers and Solutions

SEMICONDUCTOR SOLUTIONS

King Son, The Partner for Semiconductor Testing and Development

Solution



AEC-Q007-2024 Board Level Reliability (BLR) testing - for Automotive Electronics and High-Performance Computing AI Server Applications

With the advanced technology development demands of electric vehicle and AI server, automotive electronics and AI server have many complicated data management and control systems. The electric vehicle control-systems have evolved from small isolated controllers to complex distributed computer-systems, in which the signals required between each module transmitted through many independent circuits.

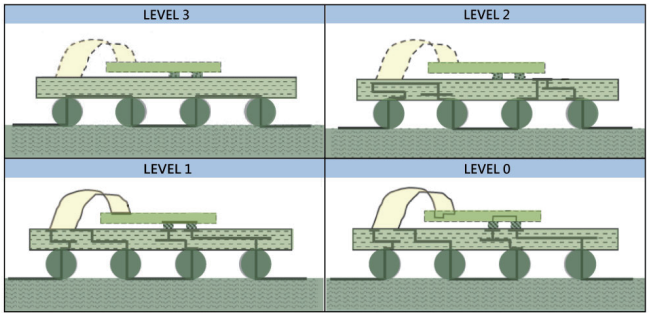
To ensure these electronic components met the highest standards for operating resilience in high-temperature and high-heat running environments, The Automotive Electronics Council (AEC) released a set of standards, including the family members of the AEC Component Technical Committee - AEC-Q100 (for IC Chips), AEC-Q101 (for Discrete Components), AEC-Q102 (for Discrete Optoelectronic Components), AEC-Q103 (for MEMS, Microelectromechanical Systems), AEC-Q104 (for MCM, Multi-Chip Modules), and AEC-Q200 (for Passive Components).

AEC released the AEC-Q007 specification in March 2024, which is for automotive Board Level Reliability (BLR) testing, designed in conjunction with PCB that details the test methods for automotive PCB and daisy chain. It elaborates on PCB and Daisy Chain designs, with Daisy Chain design being the BLR board-level reliability test commonly heard in the industry.

Board-level reliability

Ensuring board-level reliability (BLR) is particularly challenging in industries such as automotive and high-performance computing, which drive artificial intelligence (AI). In each, harsh operating environments and additional demands are increasing reliability requirements and PCB complexity. Add to this the fact that the interconnect between board and component can be a system' s weakest link, and the scope of the task becomes clear on AEC-Q007-2024 Board Level Reliability (BLR) testing.

In the past, AEC only verified the parts. AEC-Q007-2024 takes PCB into consideration for the first time. The Board Level Reliability (BLR) testing method by AEC-Q007-2024 is to verify the parts with PCB and to design the solder balls on PCB into a conductive mode to create a loop to observe the lifespan of solder joints. The solder joints life have been observed, during the BLR testing process conducted by King Son TSC Thermal Stress Complex Test Chamber, the measurement instrument, King Son VMR-S Conductor Resistance Evaluation System – Standard is used to conduct and to obtain real-time dynamic measurements information at high speed and instantly determine the solder joint yield (on-resistance should be below <20%). The purpose of the AEC-Q007-2024 testing is not to distinguish whether the parts are pass or failure, the important thing is to understand and to collect the characteristics of the parts and design the layout on the PCB board, therefore, that can conduct the temperature cycle testing for failure distribution of PCB and solder balls as a reference for subsequent design improvements.



The principle of BLR verification involves designing the solder joints and PCB in a conductive mode to create a loop to observe the lifespan of solder joints. During the testing process, measurement equipment is used to obtain real-time information for determining solder joint yield. In AEC-Q007, Daisy Chain design is divided into four levels, with Level 3 being the simplest and Level 0 being the most complex in terms of design difficulty.

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The BLR testing process needs to be dynamically monitored. The testing methods, temperature Cycling Requirements, mandated and preferred test parameters within mandated Conditions refer to the IPC-9701 specification. The temperature cycle in high and low temperature dwell time is preferably recommended to be 10~15 minutes. The IPC-9701 specification also emphasizes that exposure of assemblies to cyclic temperature changes where the rate of temperature change is slow enough to avoid thermal shock (typically less than or equal to 20°C [36°F]/min).

AEC-Q007 provides design recommendations for automotive electronics use PCBs. The number of layer recommended for automotive electronics use PCB is 8 layers (copper) and a thickness of 1.6mm.

The Board Level Reliability (BLR) testing method by AEC-Q007-2024 is to verify the parts with PCB and to design the solder balls on PCB into a conductive mode to create a loop to observe the lifespan of solder joints. The solder joints life have been observed, during the BLR testing process conducted by **King Son TSC Thermal Stress Complex Test Chamber, the measurement instrument, King Son VMR-S Conductor Resistance Evaluation System – Standard is used to conduct and to obtain real-time dynamic measurements information at high speed and instantly determine the solder joint yield (on-resistance should be below <20%).**

The purpose of the AEC-Q007-2024 testing is not to distinguish whether the parts are pass or failure, the important thing is to understand and to collect the characteristics of the parts and design the layout on the PCB board, therefore, that can conduct the temperature cycle testing for failure distribution of PCB and solder balls as a reference for subsequent design improvements.

AEC-Q007-2024 testing temperature range and temperature change rate

The BRL testing process that needs to be conducted dynamically monitored by **King Son VMR-S Conductor Resistance Evaluation System – Standard.** The testing methods, temperature Cycling Requirements, mandated and preferred test parameters within mandated Conditions refer to the IPC-9701 specification. The temperature cycle in high and low temperature dwell time is preferably recommended to be 10~15 minutes. The IPC-9701 specification also emphasizes that exposure of assemblies to cyclic temperature changes where the rate of temperature change is slow enough to avoid thermal shock (typically less than or equal to 20°C [36°F]/min).

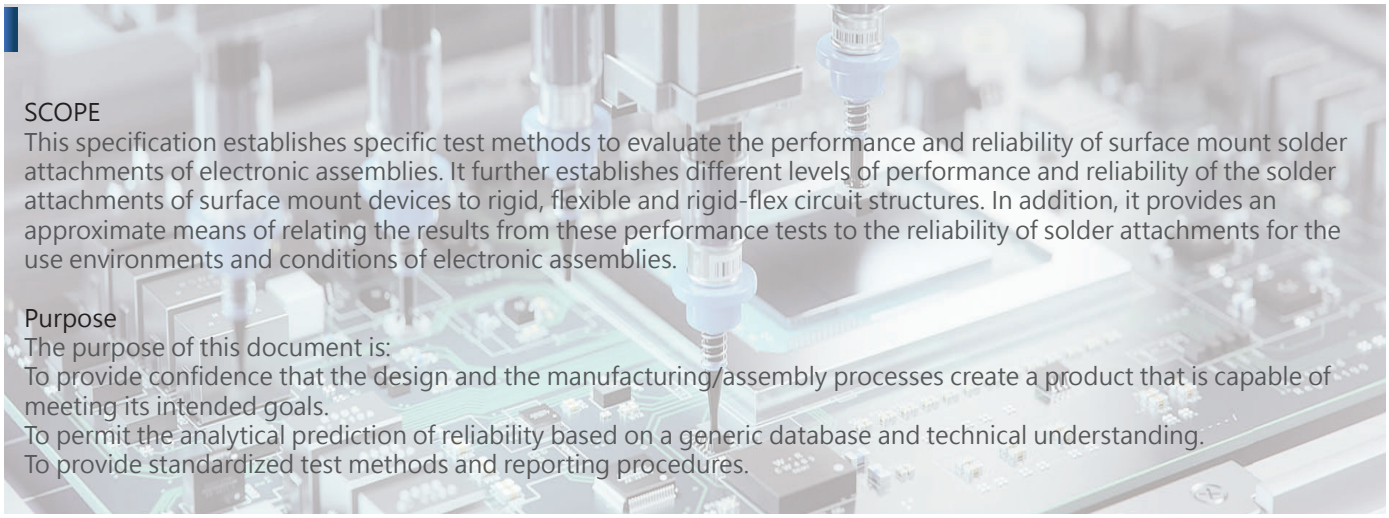
AEC BLR Temperature Cycling Conditions			
Test Condition	Temperature Range	Dwell Time	Ramp Rate
BLR-TCC-0	-40/150℃	10-15 min	<20°C/min
BLR-TCC-1	-40/125℃	10-15 min	<20°C/min
BLR-TCC-2	-40/105℃	10-15 min	<20°C/min
BLR-TCC-3	-40/85℃	10-15 min	<20°C/min

The testing temperature range selection is not based on the reliability testing temperature of the tested samples but on the actual temperature range used for the tested samples.

AEC-Q007-2024 Temperature Cycling Conditions Interpretation

1. The temperature change for the temperature cycle is adopted by a single tank with the samples under tested that does not move, instead of a double tank with the samples under tested moving.
2. The temperature must meet or exceed the expected operating temperature range of the application environment, aimed to test the life of automotive board-level reliability (BLR), not semiconductor devices.
3. The temperature control is by the air temperature
4. The dwell temperature tolerance of the samples to be tested
   a. First choice is by heating (5/-0℃), chilling (-5/+0℃)
   b. Second choice is by heating (+10/-0℃), chilling (- 10/+0℃)
5. The temperature change rate is not the heating rising rate of the samples to be tested but is the upper limit. A common temperature change rate is 10°C/min. Below 5°C/min that is proved impractical in experiments.
6. The temperature change rate is measured from the temperature under or near the samples to be tested, it is usually 10 ℃/min and not less than 5℃/min.
7. The dwell time 10~15 min. can generate to provide approximately equal damage and crack growth.
8. Excessive dwell time will lead to shortened the lifespan of tested samples.
9. The sample size for each experiment is 50 in one batch (as close as possible, IPC-9701 sample size is 32)
10. Once the failure rate is higher than 63.2%, the experiment will be terminated.
11. The measurement report must record the air temperature and the temperature of samples to be tested.

IPC-9701 application scope (reference with AEC-Q007-2024 specification)



SCOPE

This specification establishes specific test methods to evaluate the performance and reliability of surface mount solder attachments of electronic assemblies. It further establishes different levels of performance and reliability of the solder attachments of surface mount devices to rigid, flexible and rigid-flex circuit structures. In addition, it provides an approximate means of relating the results from these performance tests to the reliability of solder attachments for the use environments and conditions of electronic assemblies.

Purpose

The purpose of this document is:

To provide confidence that the design and the manufacturing/assembly processes create a product that is capable of meeting its intended goals.

To permit the analytical prediction of reliability based on a generic database and technical understanding.

To provide standardized test methods and reporting procedures.

IPC-9701A: Temperature Cycling Requirements, Mandated and Preferred Test Parameters Within Mandated Conditions

Testing Conditions	QUALIFICATION REQUIREMENTS		
	ED-4702A (Mechanical stress test methods for semiconductor surface mounting devices)		IPC 9701 (Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments
Testing temperature (Highest testing temperature)	TCA: -30℃←→+80℃		TC1: 0℃←→+100℃ (First choice)
	TCB: -25℃←→+125℃		TC2: -25℃←→+100℃
	TCC: -40℃←→+125℃		TC3: -40℃←→+125℃
	TCD: -65℃←→+125℃		TC4: -55℃←→+125℃
	TCE: Lowest←→Highest (Normally 25℃←→70℃)		TC5: -55℃←→+100℃
Number of Thermal Cycle (NTC) Requirement	Equivalent to 5 years?	Equivalent to 10 years?	Test until the cumulative failure of the sample reaches 50% (preferably 63.2%)
	TCA:1217cycles	TCA:2433cycles	200cycles
	TCB:435cycles	TCB:869cycles	500cycles
	TCC:365cycles	TCC:730cycles	1000cycles(First choices are TC2、TC3、TC4)
	TCD:277cycles	TCD:553cycles	3000cycles
	TCE:1825cycles	TCE:3650cycles	6000cycles (First choice TC1)
Low Temperature Dwell (Sample temperature)	7 minutes		**10 minutes**
Low Temperature Temperature Tolerance (preferred)	(+0℃/-10℃)		+0℃/-10℃、preferably (+0℃/-5℃)
High Temperature Dwell (Sample temperature)	7 minutes		**10 minutes**
Temperature Ramp Rate	1.5 minutes (low temperature to high temperature)		<20℃/min [JESD22-A104 typical heating rate 15℃/min, preferably recommended temperature change 10~14℃/min]
Full Production Sample Size	Not specific requirements		33 component samples (32 test samples plus one for cross-section, add additional 10 samples for rework, if applicable)
Printed Wiring (Circuit) Board (PWB/PCB) Thickness	0.6～2.4mm		2.35mm～3.15mm (>40mm for package size)
Package/Die/ MCM（Multi-Chip Module）	Daisy chain structure of die/package/ MCM（Multi-Chip Module）		Daisy chain structure of die/package/ MCM（Multi-Chip Module）
Test Monitoring during testing	Daisy chain diagram for continuous measurement, the sampling frequency depends on the actual testing status		**Use continuously dynamic measurement or data collection systems**
Failure definition	Not specific requirements		**Scan all Daisy chains that must be completed within 1 minute, in which each dwell time must be scanned and recorded for 5-times readings, that when on-resistance >20% is considered as the failure and 10 failures are recorded.**

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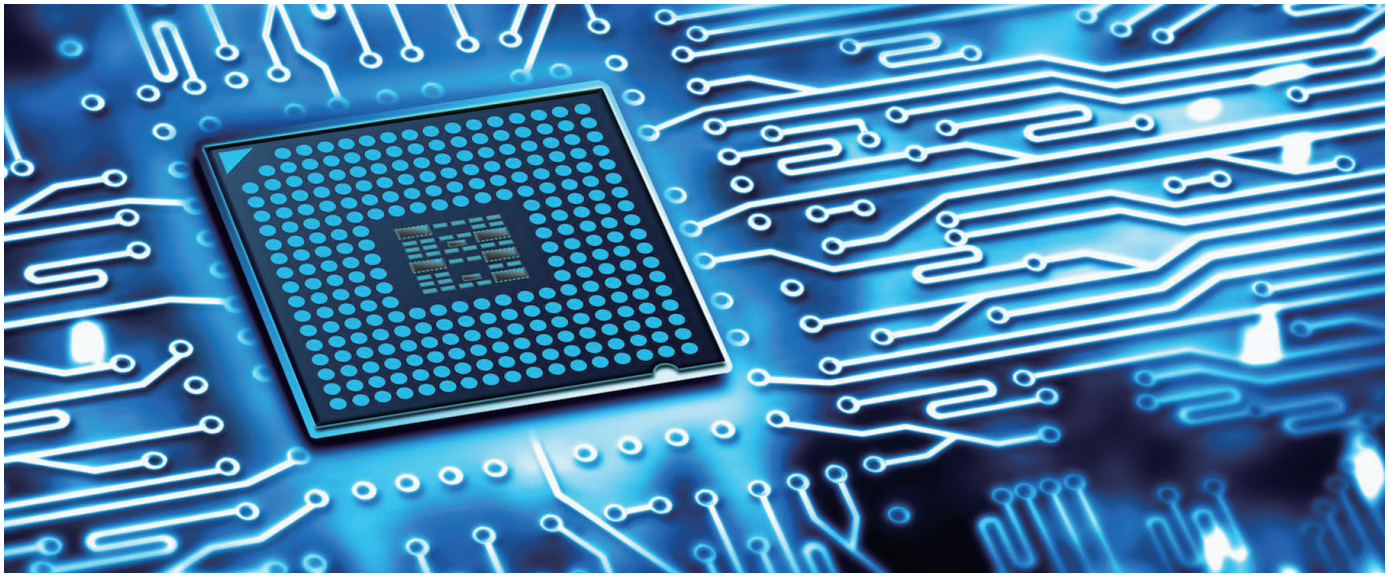

Driven by the development of new technologies from electric vehicles, automotive electronics, smart sensors, 5G communication, wearable devices, High-Performance Computing (HPC), Generative Artificial Intelligence (AI), artificial intelligence (AI) and machine learning (ML) data center, cloud computing and storage etc., the global demands for advanced semiconductor manufacturing technology continues to increase rapidly.

King Son is the prominent collaborative environmental test chamber and solution partner for key innovations in ICT industry since found 1983.

Through its OEM/ODM project partnership co-operation with Top 10 Taiwanese EMS (Electronic Manufacturing Services) giants accounting for 75% EMS business globally and leveraging the advantages of Taiwan' s critical role in making 90% of most advanced semi-conductor chips, King Son' s proprietary environmental test chamber and solution are uniquely positioned to play a leading role in the innovation value chain of established technology players like Apple, Nvidia, NXP, ASE and upcoming disruptors within the semiconductor sector.

Rising Global Demand

Semiconductors are crucial components of all emerging technologies from 5G networks to AI and green electricity. Semiconductor demand will continue to increase approximately 4-5% per year, with an estimated need for an increase in semiconductor manufacturing capacity of over 50% by 2030.

RELIABILITY AND SAFETY

The evolution of semiconductor manufacturing technology has also made integrated circuit electronic components size smaller.

The smaller the IC components size, the semiconductor product testing reliability such as warping, delamina-

King Son Test Chambers and Solutions for Semiconductor

With the properties of both a conductor and an insulator, a semiconductor is commonly found in most electronic devices, mainly software chips and batteries. Silicon is one of the most common materials labeled as a semiconductor. The quality of a semiconductor is determined by temperature and can be dramatically altered because of it. King Son offers temperature and humidity testing chambers that aid in determining reliability of the product based on rigorous conditions it may be prone to due to temperature conditions.

For example, the novel King Son VMR series (VMR-S, VMR-F, VMR-3A) evaluation system and SIR measurement system can conduct the customization design integration test either with King Son made or 3rd party brand Temperature Cycling Test Chamber, Thermal Shock Test Chamber, HAST+ Highly Accelerated Stress Test Chamber, Constant Temperature and Humidity Test Chamber or Electric-dynamic Shaker.

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The VMR series (VMR-S, VMR-F, VMR-3A) evaluation system in each interaction test maximum can integrate with up to 8 test chambers.

The SIR measurement system in each interaction test maximum can integrate with up to 5 test chambers.

INTEGRATION TEST

King Son TSC Thermal Stress Complex Test Chamber interaction test with King Son VMR-S Conductor Resistance Evaluation System – Standard.

King Son TSC + VMR-S integration test is applicable for various automotive electronics materials, parts, and components soldering joints tests includes fixed-point temperature test, high temperature and high humidity test, high and low temperature thermal shock test, high and low temperature rapid temperature cycle test, highly accelerated life aging test, and various environmental reliability tests.

King Son TSC + VMR-S integration test is capable to conduct environmental reliability tests for automotive electronics material, parts, and components such as FPC, PCBA, resistors, inductors, capacitors, BGA & CSP solder joints, and advanced semiconductor packaging tests (Sip, SoC, WLP, PLP, FOWLP, 3D-IC, FCin MCep, FCBGA, Fc CSP, etc.) that assist customers to analyze the parts, components soldering joints reliability evaluation in the finished product quickly and effectively.

King Son HAST+ Highly Accelerated Stress Test Chamber interaction test with King Son SIR Surface Insulation Resistance Measurement System

King Son HAST + interaction test with King Son SIR is designed to provide high humidity 85% R.H, increase the test temperature and pressure to accelerate the aging test of automotive electronics parts, components, materials and shorten the test time of life test.

King Son SIR Surface Insulation Resistance Measurement System interaction test with King Son THS Programmable Constant Temperature and Humidity Test Chamber, ATSK Thermal Shock Test Chamber, HAST+ Highly Accelerated Stress Test Chamber

King Son Semiconductor Test Chambers and Solutions

King Son THS

King Son THS Programmable Constant Temperature and Humidity Test Chamber (Standard Type)

In accordance with test standards ISO16750, LV 124, AECQ-200, IEC60068-2, King Son THS Programmable Constant Temperature and Humidity Chamber is designed to conduct condensation and dew condensation tests (included by humid heat temperature cycle test, combined temperature and humidity cycle test, humidity resistance test) for electric vehicles and automotive electronics.

Besides that, the accelerated aging life test, temperature gradient test, specified temperature change rate temperature cycle test, heat soak temperature cycle test, etc. are also included to meet the test requirements for electric vehicles and automotive electronics.

King Son ATSK

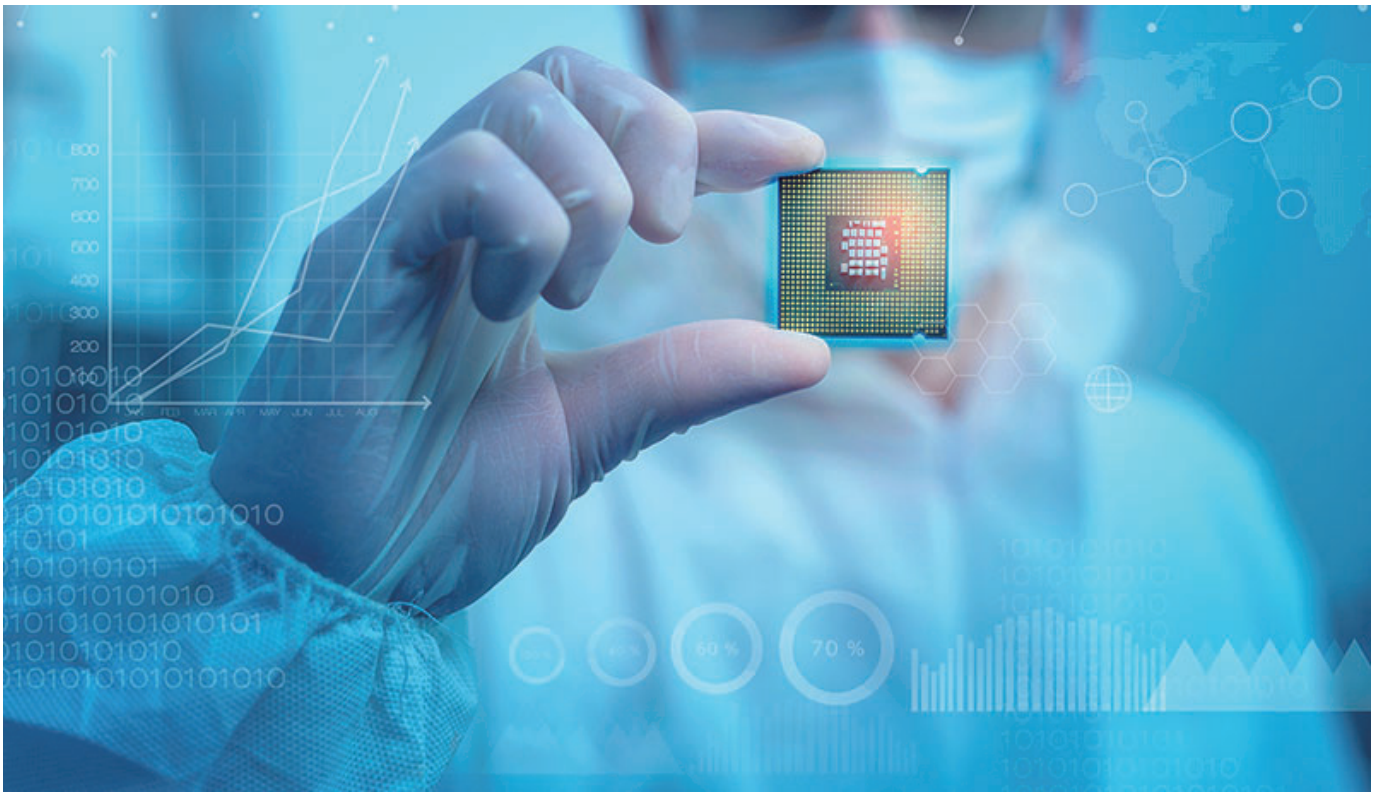
King Son ATSK Air to Air Thermal Shock Test Chamber

The Advanced Thermal Shock(ATSK)chamber is more advanced than before. Lower times of defrosting saves the time and energy. It can also control ramp rate via expansion. Design for the basic of international standards, it is stable and reliable for testing.

King Son HAST+

King Son HAST+ Highly Accelerated Stress Test Chamber

King Son HAST+ Highly Accelerated Stress Test Chamber is designed to conduct constant high-humidity environment (85% R.H.) test, which increase the temperature and pressure, and perform accelerated life tests [JESD22-A110, JESD22-A118] for automotive electronics parts, components and materials, effectively shortening the traditional high-temperature and high-humidity test time [JESD22-A101], It can also perform forced moisture absorption and destructive tests under high pressure (100% R.H.) [JESD22-A102].



King Son Semiconductor Test Chambers and Solutions

King Son VMR-S Conductor Resistance Evaluation System – Standard

King Son VMR-S Conductor Resistance Evaluation System – Standard is designed to conduct high-speed measurement, recording, and data analysis for various electronic parts, components, materials, and its soldering joints tests.

King Son VMR-S Conductor Resistance Evaluation System – Standard is designed to conduct environmental reliability tests for automotive electronics such as FPC, PCBA, resistors, inductors, capacitors, BGA & CSP solder joints, and advanced semiconductor packaging tests (Sip, SoC, WLP, PLP, FOWLP, 3D-IC, FCin MCep, FCBGA, Fc CSP, etc.) that assist customers to analyze the parts, components soldering joints reliability evaluation in the finished product quickly and effectively.

King Son VMR-F Conductor Resistance Evaluation System - PLUS

In response to the high data volume and high-speed transmission between 5G and the Internet of Vehicles, the related electronic parts, and components (PCB/electronic components/semiconductors) require faster and larger current measurement methods.

King Son Conductor Resistance Evaluation System – PLUS is designed capable to conduct and measure the 400-channel of solder joints and test the solder joints reliability of specimens at high speed within 60 seconds, and also can combine various reliability test methods, such as fixed point temperature test, DH high temperature and high humidity test, TST high and low temperature thermal shock test, TCT high and low temperature rapid temperature cycle test, HAST Highly Accelerated Stress Test that can analyze the strength and reliability of solder joints in specimen quickly and effectively.

King Son VMR-3A Conductor Resistance Evaluation System- High Current

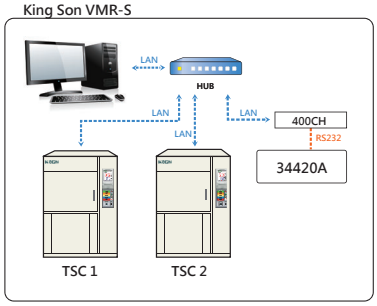
Electric vehicle is the trend of future technology. Car manufacturers and parts, components suppliers are also investing in research and development and production to meet the speed and horsepower driven by consumers.

The power supply system and parts, components used for electric vehicle running consume high voltage and high current, the used voltage is as high as more than 400 voltages, and the used current will be also higher above 1.5 ampere.

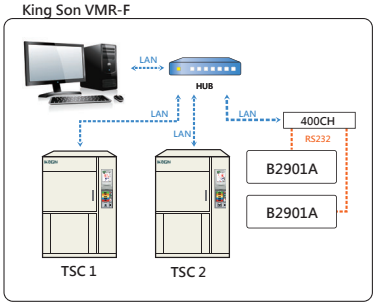
The longer time test method required by traditional vehicle regulations can no longer meet the test requirements for electric vehicle.

Increase the test stress can shorten the test time that King Son VMR-3A Conductor Resistance Evaluation System – High Current provide maximum 3 ampere measurement current to meet and exceed the test regulation requirements of next generation electric vehicle.

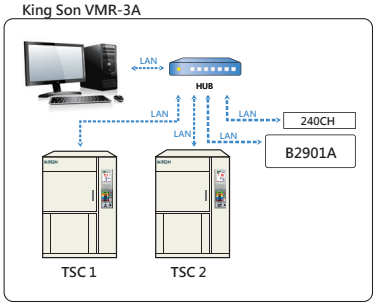
King Son VMR-S



King Son VMR-F



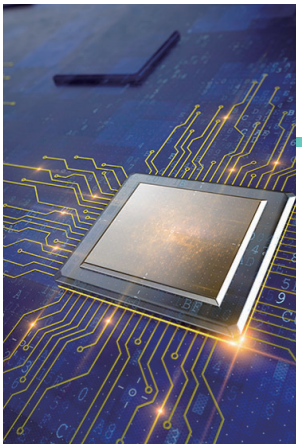
King Son VMR-3A



King Son SIR Surface Insulation Resistance Measurement System

King Son SIR is a scanning type designed Surface Insulation Resistance Measurement System (SIR-2006B-250V) that can expand the migration measurement up to 200 channels and breaks through the limits that the traditional scanning surface insulation resistance measurement system cannot records the migration ending time and also cannot records the happened time of migration, that customers can get the maximum production benefit with the least minimum equipment cost.

Industry Integration Test



King Son TSC Thermal Stress Complex Test Chamber + King Son VMR-S Conductor Resistance Evaluation System – Standard

King Son TSC + VMR-S integration test is designed to conduct high-speed measurement, recording, and data analysis for various electronic parts, components, materials, and its soldering joints tests.

King Son TSC + VMR-S integration test is applicable for various automotive electronics and its soldering joints tests includes fixed-point temperature test, high temperature and high humidity test, high and low temperature thermal shock test, high and low temperature rapid temperature cycle test, highly accelerated life test, and various environmental reliability tests.

King Son TSC + VMR-S integration test is capable to conduct environmental reliability tests for automotive electronics such as FPC, PCBA, resistors, inductors, capacitors, BGA & CSP solder joints, and advanced semiconductor packaging tests (Sip, SoC, WLP, PLP, FOWLP, 3D-IC, FCin MCep, FCBGA, Fc CSP, etc.) that assist customers to analyze the parts, components soldering joints reliability evaluation in the finished product quickly and effectively.

King Son HAST+ Highly Accelerated Stress Test Chamber+ King Son SIR Surface Insulation Resistance Measurement System

King Son HAST+ and SIR integration test is designed to provide high humidity 85% R.H, increase the test temperature and pressure to accelerate the aging test of automotive electronics parts, components, materials and shorten the test time of life test.

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The environmental reliability testing standards for Electric Vehicles and automotive electronics and applicable testing chambers

Testing chamber	Testing standards	Testing item
THS Constant Temperature and Humidity Chamber	ISO16750 LV 124 L-03 AEC Q-100 AEC-Q101 AEC-Q200 IEC60068-2	Pre-Condition Temp. and Humidity Bias High Temp. Storage Life High Temp. Operating Life
TSC Thermal Stress Chamber (Temperature Cycling)	ISO16750 LV124 L-03 AEC-Q100 AEC-Q101 AEC-Q200 AEC-Q007	Temp. Cycling - Ramp
ESS Environmental Stress Screening Test Chamber	Iec60068-2-14 Nb MIL-2164A GJB-7243	Temperature cycle test
ATSK Thermal Shock Tester (Air to air type)	AEC-Q200	Power Temp. Cycling
HAST+ Highly Accelerated Stress Test Chamber	AEC-Q100 AEC-Q101 IEC 60068-2-66 IEC 60749-4 JESD-22-A102-C JESD-22-A110C JESD-22-A118 JIS C60068-2-66 JEITA ED-4701/100	Pre-Conditioning Biased HAST Autoclave Unbiased HAST

Condensation test

Temperature & humidity test (Humidity freeze test)

Temperature cycle test

www.kingson-global.com

ISO 9001 : 2015

Quality Management Systems
King Son Instrument Tech. Co., Ltd.
has established and applies
a Quality Management System for
Development, Production and Distribution of Temperature & Humidity Chamber, Walk-In Chamber, Thermal Shock Tester, Oxidation-Free Oven, HAST (Highly Accelerated Stress Tester), High Pressure Accelerating Life Tester and Convertible IFP (Initial Freezing Point) Food-Tech Chamber.

*Certification Body of TÜV SÜD Asia Ltd. Taiwan Branch Management Service Department

ISO 14001 : 2015

Environmental management systems
King Son Instrument Tech. Co., Ltd.
has established and applies
an Environmental Management System for
Development, Production and Distribution of Temperature & Humidity Chamber, Walk-In Chamber, Thermal Shock Tester, Oxidation-Free Oven, HAST (Highly Accelerated Stress Tester), High Pressure Accelerating Life Tester and Convertible IFP (Initial Freezing Point) Food-Tech Chamber.

*The Certification Body of TÜV SÜD Asia Pacific TÜV SÜD Group

R448A refrigerant,
an excellent replacement for R404A

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