SMART ENVIRONMENT 5000 SERIES

5200 Satellite Payload Test Environment

AEROFLEX
A passion for performance.

- **Complete Synthetic Test Environment**
  Hardware, software, processes, support
- **Optimized for Satellite Payload Test**
- **Highest Test Throughput Available**
- **Proven Systems Deployment**
  5th generation solution – major customers worldwide
- **Full Range of Required Mixed Signal Capabilities**
  DC, digital, analog, RF/microwave
- **System Level Architecture**
  Calibration, verification, alignment
- **Open System Architecture**
  System hardware and software, TPS'

The SMART^E 5200 Satellite Test Environment is a member of the SMART^E 5000 Series, which is a complete test solution environment from Aeroflex. The Model 5200 encompasses hardware, software, test practices and support along with standard and customizable test programs tailored to the specific problems of testing high performance payloads. Such payloads consist of many channels with possibly hundreds of connections between the test system and payload under test.

The Aeroflex SMART^E 5000 Test Environment is based upon the 5th generation evolution of Aeroflex's synthetic test technology. Aeroflex synthetic test systems are successfully deployed in a variety of high performance test applications including Satellite Payload test, Advanced Satellite Payload test, high speed T/R Module testing and military ATE.

Aeroflex began shipping synthetic test systems for payload testing in 1997, providing the industry's highest available throughput and accuracy for testing of satellite payloads. The product roadmap has evolved over the past several years from two-rack systems populated with proprietary components to systems composed primarily of COTS components at about half the size and power consumption, enhanced reliability/availability/maintainability, extended frequency range, and reduced cost when compared with the initial systems.

SMART^E fundamentally brings about the advantages of integrating COTS system components from multiple vendors in the Aeroflex hybrid test environment thus providing a cost effective test solution fully optimized for the requirements of the devices to be tested. The SMART^E 5200 provides greater configurability through COTS modularity characterized by the use of recognized and well established industry standards, a highly developed software suite, proven operational test practices, and long-term, leadership support programs. The finely balanced combination of these attributes is what makes SMART^E a complete environment offering all the convenience and advantages brought by a single-vendor system responsibility.

Synthetic test environments offer the lowest total cost of test, largest throughput increases, and typically take less than half the rack space, weight, and power consumption/heat generation of conventional, rack-and-stack instrument-based systems. In addition, even for hybrid configurations, the number of instruments and associated dedicated measurement paths is reduced. Thus, the scope and complexity of calibration is also reduced. Furthermore, since most groups of measurements for any given configuration utilize the same downconverter – digitization channel, there is a much greater time correlation and lower uncertainty among these measurements than when individual instruments are sequentially multiplexed.

SMART^E 5200 40 GHz Satellite Payload Test Environment

Typical SMART^E 5200 Characteristics

A SMART^E Model 5200 Satellite Payload Test Environment may be flexibly composed of various combinations of the following hardware, software and support elements.

Hardware

Stimulus Subsystem Including

- One or more Synthetic RF/microwave stimulus channels operating from DC to 8, 12, 20, 26.5 or 40 GHz in pulsed, CW or AWG source modes
- Auxiliary stimulus channel(s) for multi-tone measurements or other multi-source applications
- Options to combine the two stimulus channels into one 900 MHz broadband, multi-carrier stimulus
- Power amplifier units to provide high output power at the payload
- Numerous choices of other mixed signal stimulus components.

Measurement Subsystem Including

- One or more synthetic RF/microwave response measurement channels configured for operation to 8, 26.5 or 40 GHz with an RF bandwidth of 400 MHz, and either narrowband or both narrowband and broadband digitizer subsystems
- Optional auxiliary measurement channels implemented as synthetic channels or as specific purpose instrumentation components
- High performance digitizers which may be used for any of a variety of signal capture functionalities.

Signal Calibration and Routing

- Local Calibration Unit (LCU) for calibrating RF/microwave signals to NIST traceable standards
- TVAC compatible Remote Calibration Units (RCUs) that provide signal multiplexing and remote calibration support for up to 384 ports
- Support for unique calibration techniques that correct for amplitude and phase drift due to temperature changes in TVAC environment

Software

- Microsoft Windows® operating system with Microsoft Office®
- National Instruments TestStand - Test Management Software
- Aeroflex Measurement Console (AMC) - sequencer and user operating interface
- Aeroflex designed API DLL functions enabling customer driven interfaces to be connected to the system
- Satellite Payload Measurements Library
- General measurements library
- Test customization
- Simulator software

Test Practices

- Hierarchical Calibration
  - Base, operational, reference plane extensions
  - Base Cal requires calibration of only a few transfer standards, not the synthetic components (i.e., the test environment does not require disassembly)
- System verification while the payload is connected even in TVAC
- Built-in reference plane extension from the calibration plane to the test ports plane via measurements or s-parameter files
- Uncertainty specifications at the system level

Support

- System Diagnostics to Field Replaceable Unit module level
- Regional spares pools
- Guaranteed response-time service
- Customer self-support training
- Remote expert direct connect – assistance via internet

Satellite Payload Testing Using the SMART^E 5200

Aeroflex has more than ten years of experience in fielding synthetic test systems specifically configured for testing of satellite payloads. Customers utilize the same systems for all stages of integration and test of a payload including panel testing, reference performance testing of the full payload, testing in a thermal vacuum chamber and antenna range testing in anechoic chambers.

There are numerous similarities among satellite payloads across the vendors who supply them. On the other hand, no two payloads are exactly alike and no two manufacturers have precisely the same test strategies and methodologies. Consequently, while there are many common core elements among each of the Satellite Payload Test Systems implemented and sold by Aeroflex, there are also unique aspects for systems provided to any single customer.

From a test system vendor perspective, the objective is to create a test environment solution based upon a necessary and sufficient core capability. This core capability addresses the common aspects of satellite payload test but remains flexible enough so that it can be easily customized to match the unique requirements of any given payload and associated customer.

While evolving to the 5th Generation SMART^E test environments, Aeroflex first changed the implementation of the core RF/microwave functions to be more modular in terms of the frequency ranges and power characteristics to be provided for the various applications. In fact, satellite payloads operate at different frequencies and different power levels depending upon the system application/mission to which they are applied. Frequency and power are two of the most basic cost drivers for microwave equipment. Consequently, the most cost efficient solution is inevitably going to be associated with the test system that optimally and dynamically matches the range of frequency and power characteristics of the modules to be tested.

Thus, configuration of a SMART^E solution begins with the selection of the stimulus and measurement channel modular base components associated with the required operating frequency ranges. Subsequently, an assessment is made for the selected modules to be able to handle the overall power levels required by the test plan and Satellite Payload characteristics. As a result, either standard modules/system input/output power will be sufficient, or a customized variable attenuator/power amplifier subsystem option will be seamlessly added to the standard modular solution.

Aeroflex supplies a standard library of common tests as shown in Table 1.

Gain Transfer/ALC Characteristics	Group Delay/Phase vs. Frequency
Frequency Response	Noise Power Ratio (NPR)
Frequency Conversion	Passive Intermodulation (PIM)
Spectrum, Spurious	Fixed Gain Steps
Amplitude Linearity	ALC Gain Steps
AM to PM Command	Threshold
Channel Isolation	Multicarrier
Noise Figure	Multicarrier Phase Peak
Modulation Index	Relative Amplitude and Phase

Table 1. Satellite Payload Test Library

In addition to these standard tests, new test sequences can easily be developed by Aeroflex or a customer to meet new measurement requirements.

As part of the SMART^E environment, Aeroflex provides a universal test management interface called the Aeroflex Measurement Console (AMC). From this interface, the test engineer or operator may select and execute tests, create sequences of tests, input variable parameters, access test results, set up default settings and parameters, and perform a wide variety of test related functions.

Figure 1 illustrates the topology of the AMC User Interface. This includes a tree view of test sequences saved in a file, an area for user interactive input of variable parameters presented by the test sequence, and a window for viewing the results of the tests. Test data are presented in graphs, and tables and records of various scalar values associated with the test. Examples include test execution times and all the parameter settings active at the time of execution of the test, as well as error logs or logs of the steps individually followed in executing the test.

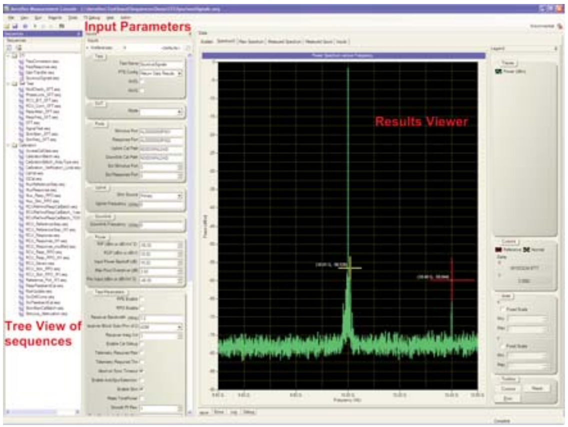

Fig 1. Topology of the Aeroflex Measurement Console (AMC)

Figure 2 depicts the application of the AMC to a payload test when an amplitude linearity test has been executed and displayed in a graph showing a spectrum of the downlink signal.

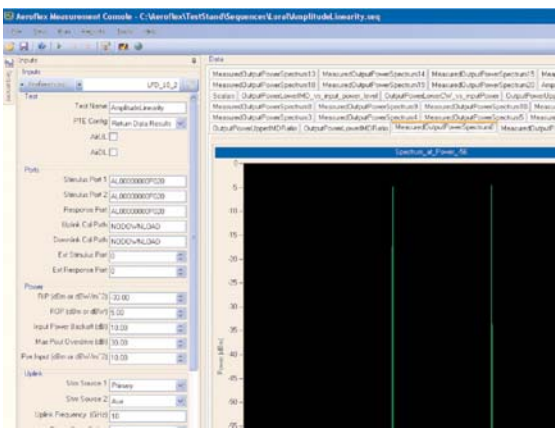

Fig 2. Amplitude Linearity Measurement

Selecting another tab in the results display window (Figure 3) provides access to a plot of intermodulation power versus input power.

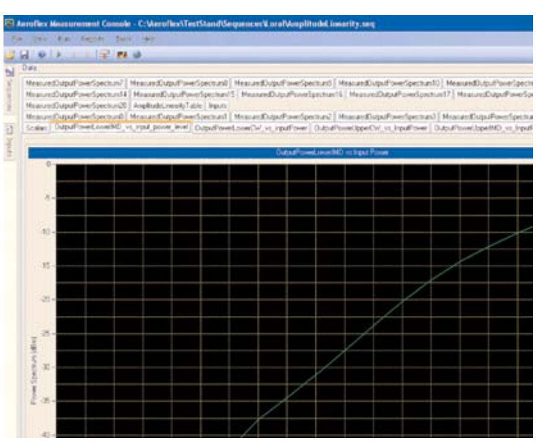

Fig 3. Intermodulation Power

The test results area is programmed as a tabbed window where various result format choices and derivative tabulated data sets may be presented as seen in Figure 4. Results can be automatically saved to files with formula names reflecting tests, and date and time of execution. Integration with existing data storage schemas is easily implemented. All results can be exported to Excel and XML.

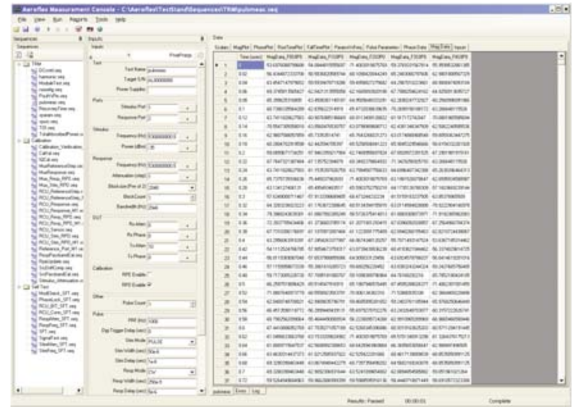

Fig 4. Tabulated Measurement Results

The test results may be transferred to an Excel workbook with the tabbed results mapped to spreadsheets on a one-to-one basis as illustrated in Figure 5.

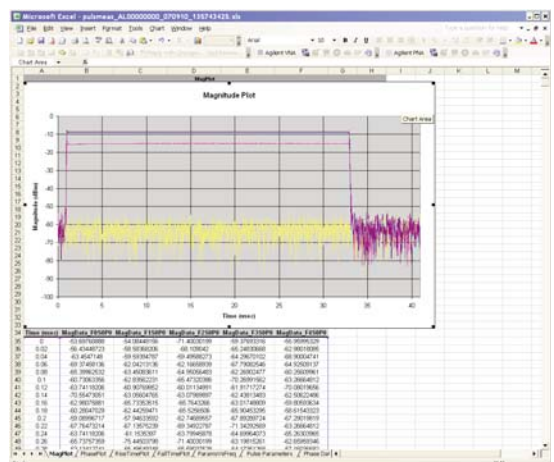

Fig 5. Test Results Exported to Excel Workbook

Graphical analysis and interpretation tools are provided in conjunction with the results window. Figure 6 shows the results of a measurement with cursors enabled to provide interactive interpretation of the data.

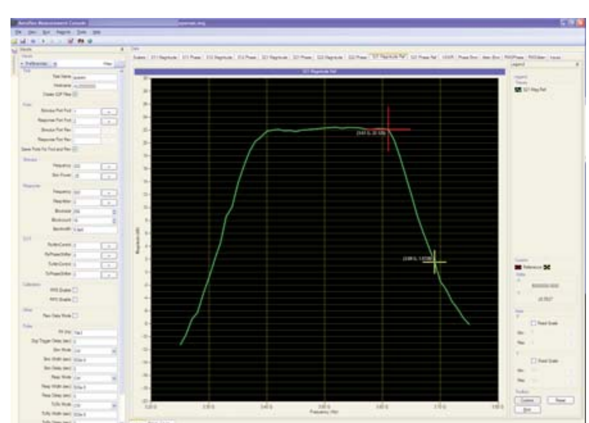

Fig 6. Plot with Cursors Activated

SMART^E 5200 Summary Options

The following table lists the baseline components and options for the 5200.

Item	Description
Frequency Ranges	Base system frequency coverage: ■ 50 MHz to 8 GHz Options: ■ Extend stimulus and response to 12 GHz ■ Extend stimulus and response to 20 GHz ■ Extend stimulus and response to 26.5 GHz ■ Extend stimulus and response to 40 GHz
Stimulus Modulation	Base system modulation: ■ CW ■ AM, FM, PM ■ Narrowband arbitrary stimulus waveforms Modulation Options: ■ Wideband arbitrary stimulus waveforms
Number of Ports	Base system ports with 1 RCU: ■ 32 ports (Uplink and Downlink) Options: ■ Up to 5 additional 32 port RCUs

SPECIFICATIONS

Satellite testing features

The SMART^E 5200 configuration is optimized for measurements of Satellite Payloads and associated subsystems

The SMART^E 5200 provides standard payload measurements with best-in-class uncertainty and measurement speed

The SMART^E 5200 provides broad band multi-carrier stimulus and measurement capability

TVAC compliant multiplexer units (RCUs) support up to 384 ports

A unique calibration scheme provides extremely accurate measurements at the plane of the payload interface

SMART^E 5200 Performance Specifications

The stimulus, response and measurement performance of the SMART^E 5200 system are specified for typical operating conditions

The majority of the specifications apply at the forward and reverse ports of the system

Measurement uncertainties apply to a configuration with the RCUs located up to 50 feet (15 meters) from the main equipment rack

The following measurement types are supported by the SMART^E 5200

- *Gain Transfer/ALC Characteristics*
- *Frequency Response*
- *Frequency Conversion*
- *Spectrum and Spurious Search*
- *Amplitude Linearity*
- *AM/PM*
- *Channel Isolation*
- *Noise Figure*
- *Modulation Index*
- *Group Delay/Phase versus Frequency*
- *Absolute Time Delay*
- *Noise Power Ratio*
- *Passive Intermodulation*
- *Multi-Carrier Test*
  - *Relative Amplitude and Phase*
  - *Phase Peaking*
- *Payload Control Tests*
  - *Fixed and ALC gain Steps*
  - *Command Threshold*

STIMULUS SPECIFICATIONS

Parameter	Specification	Comments
Number of sources	2 internal (Primary, AUX) 1 external port for additional source	External source is CFE
Carrier spacing	0 to 40 GHz	
Frequency range	0.1 to 40 GHz	
Instantaneous BW Wideband Narrowband	 450 MHz 30 MHz	
Frequency band overlap	> 200 MHz	Primary stimulus
Power Range	100 dB range	
Power resolution	0.1 dB	
Spectral Purity (narrowband)	-70 dBc (+/- 500 MHz from center)	Excluding power line spurs, spur identification part of spur tests as required
Output power (CW mode) Rack Output RCU Output	 +10 dBm -24 dBm	 -30 dBc IM spec at RCU output with 50 ft (15 meters) of cable
SSB Phase Noise	Freq Offset dBc/Hz <26.5 GHz dBc/Hz <40 GHz 10 Hz -50 -45 20 Hz -60 -55 100 Hz -75 -70 1 kHz -90 -85 10 kHz -92 -92 100 kHz -110 -105 1 MHz -125 -120	
Modulation Types	CW, AM, FM, PM, NPR, multi-carrier	Combinations of modulation types available
Glitch free power range Positive glitches Positive and negative glitches	 80 dB 36 dB	
Carrier to noise	>110 dB-Hz	
NPR Stimulus Noise bandwidth Notch bandwidth Notch Depth	 0.5 to 80 MHz 50 KHz to 5 MHz 40 dB minimum	
Multi-Carrier Stimulus	2 independent channels, 450 MHz bandwidth per channel	Can be combined to generate a single stimulus signal covering 900 MHz of instantaneous BW
Auxiliary switched outputs	Primary, Auxiliary, Combined primary and auxiliary	Primary and Auxiliary can also be combined with external source (CFE)
Number of ports	Up to 192 RCU uplink ports Up to 384 RCU uplink ports 1 dedicated primary uplink port 1 secondary or combined uplink port	6 RCUs with 32 stim + 32 Resp 6 RCUs with 64 stim At the MUX interface At the MUX interface
Port-To-Port Isolation	> 65 dB	
Outputs to RCU	Any combination of Primary/Auxiliary/External to RCU	
External 10 MHz reference	All internal references can be phase locked to external reference	
Uplink return loss < 18 GHz 18 to 40 GHz	 18 dB 15 dB	 At the RCU interface Uncertainty analysis includes these return loss values

Notes:

1. Requires Arbitrary Waveform Generator option.

RESPONSE SPECIFICATIONS

Parameter	Specification	Comments
Frequency Range	0.1 to 40 GHz	
Instantaneous BW Wideband Narrowband	 450 MHz 30 MHz	
Frequency band overlap	> 200MHz	
Number of ports	Up to 192 RCU downlink ports Up to 384 RCU downlink ports 1 dedicated downlink input port 1 dedicated downlink output port	6 RCUs with 32 stim + 32 resp 6 RCUs with 64 resp At the MUX interface Available at the MUX interface to connect to an external instrument (CFE).
Port-To-Port Isolation	> 65 dB	
External 10 MHz reference	All internal references can be phase locked to external reference	
Maximum downlink power at rack	+30 dBm	
Maximum downlink power at RCU	+26 dBm	At 50 degrees C
Downlink return loss <18 GHz 18 to 40 GHz	 18 dB 15 dB	 At the RCU interface Uncertainty analysis includes these return loss values

MEASUREMENT SUMMARY SPECIFICATIONS

The following table summarizes the tests that are available for the 5200 satellite measurement system. Individual Measurement Reference Descriptions (MRDs) are available for each test that provide details on the operation, input parameters and output data products available from each test.

Measurement Name	Summary Description	Typical Uncertainties(1)
Gain Transfer/ALC Characteristics	This test measures the CW output power versus the CW input power. Options include ALC or non ALC mode in the payload and saturation calculations.	+/- 0.3 dB
Frequency Response	This test measures the frequency response of a channel or portion of channel. Data products include gain, relative gain, output power, gain flatness and gain-slope.	+/- 0.3 dB (to -20 dBc) +/- 0.4 dB (to -50 dBc)
Frequency Conversion	This test measures the output frequency and power of the channel under test. The stimulus signal may be applied as part of the test. If a stimulus signal is provided, the frequency difference between stimulus and response is also provided.	+/- 134 Hz
Spectrum, Spurs	This test measures the spectrum of the downlink signal over a user-defined bandwidth and resolution. In addition this test measures the in-band and out-of-band spurious performance of the channel. This test can be run with or without an uplink stimulus signal.	+/- 0.3 dB (to -30 dBc) +/- 1.0 dB (to -60 dBc) +/- 2.5 dB (to -70 dBc)
Amplitude Linearity	This test measures the inter-modulation distortion (IMD) products as a function of input power level.	+/- 0.3 dB (to -30 dBc)
AM to PM	This test characterizes the phase non-linearity of the payload by measuring the AM/PM conversion factor of the channel under test.	10% or 0.3 deg/dB whichever is larger
Channel Isolation	This test measures the isolation between two specified channels. Data products include the reference output power of each channel and the isolation between channels.	+/- 0.5 dB (to -50 dBc) Degrades to +/- 1.5 dB at -75 dBc)
Noise Figure	This test measures the noise figure of the payload or a section of the payload. This is accomplished by measuring the DUT response in the presence and absence of the stimulus signal.	+/- 0.5 dB
Modulation Index	The purpose of this test is to measure the modulation index of the downlink signal. This test can be performed with or without a stimulus signal.	+/- 0.04 radians
Group Delay (relative)/Phase vs. Frequency	This test measures the group delay of a channel or portion of channel. Data products include group delay, group delay slope and group delay ripple. In addition, normalized phase is also provided across the measurement bandwidth of interest.	+/- 0.7 ns (< 26.5 GHz) +/- 1.2 ns (< 26.5 GHz) See note (2)
Noise Power Ratio (NPR)	This test measures the Noise Power Ration (NPR) as a function of input power. The measurement is defined as the ratio of the noise power spectral density outside of a narrow notch to that within the notch.	+/- 0.5 dB
Passive Intermodulation (PIM)	This test measures the passive inter-modulation distortion (IMD) products which may fall in the return transponder's receive band.	See spectrum measurement peformance
Gain Steps Fixed Gain Mode or ALC Gain Mode	This test measures the input and output power as a function of the transponder attenuators.	+/- 0.3 dB
Command Threshold	The purpose of this test is to determine the lowest uplink power level where the receiver acquires or loses a "lock status". The test can also be performed by varying the input frequency (as opposed to power).	+/- 0.3 dB
Multicarrier	The purpose of this test is to generate up to 32 signals from each of the 2 RF sources. These signals are CW. Unique inputs are the amplitude, phase, and frequency. The multi-carrier signal can cover up to 900 MHz of instantaneous BW.	Power setability of carriers to +/- 0.5 dB with power optimization
Multicarrier Phase Peak	The purpose of this test is to generate and adjust the amplitude and phase of groups of tones (separated in frequency) in order to maximize the output power of a payload combiner at a single frequency. The test can generate and adjust multiple groups of tones.	Power setability of carriers to +/- 0.5 dB with power optimization
Relative Amplitude and Phase	This test measures and CW output power and/or phase for a list of ports and associated parameters. The stimulus signal is a multi-carrier signal covering up to 900 MHz of instantaneous bandwidth.	+/- 1.0 deg (< 3 GHz) +/- 2.0 deg (< 21 GHz) +/- 3.0 deg (< 31.5 GHz)
Time Delay	This test measures the absolute time delay of a through the selected channel.	+/- 5 ns (standard cal) +/- 0.5 s (frequency trans calibration)

Notes:
1. 2 sigma uncertainty assuming 50 ohm load. Typical values for system with RCU located up to 50 feet (15 meters) from the rack.
2. Better performance available through the use of frequency translating calibration technique.

FREQUENCY SPECIFICATIONS

Parameter

Reference Frequency

10 MHz

Reference Stability

3×10^{-11}/second

5×10^{-11}/month

0.3×10^{-11}/°C

Reference Connections

Cable installed between the internal reference output and the system reference input to run the system from the internal reference.

Remove the cable to connect an external reference to the system reference input.

(1) BNC Internal Reference Output

(1) BNC Reference input

(1) BNC Reference Output

Reference Level

High power option available to boost the output signal to 13 dBm

Output 0 dBm

Input 0 dBm

PHYSICAL AND ENVIRONMENTAL SPECIFICATIONS

Parameter

Physical form factor

Standard single-bay 19" EIA rack - EMC style rack with shielding gaskets on all doors and interface panels.

Dimensions

Height	78"	Without lift bolts
	81"	With lift bolts
Width	28"	Does not include isolation base
Depth	46"	Does not include isolation base

AC Input Voltage

110 – 230 VAC	System uses a single phase
50/60 Hz	Optional cooling unit may use a second phase

Power Consumption (excluding DUT power supplies)

< 3,000 Watts

AC Input Connector

NEMA L21-30 System mains power

AC Outlet Connector

IEC-320 Auxiliary AC outlet

Ground Connector

5/16" Threaded Stud — Located at the bottom of the rack near the AC inlet connector

Temperature Range

Operating	0 to 40 °C
Non-Operating	0 to 45 °C

Altitude

Operating	6,500 feet/2,000 meters
Non-Operating	40,000 feet/12,000 meters

Humidity

Operating	10-90% RH (non-condensing)	
Non-Operating	5-93% RH (non-condensing)	Non-condensing

Safety Standards

EN 61010-1, IEC 61010-1

EMC Standards

EN 61326-1, IEC61010-1

Transportation

System includes (4) 4-inch locking casters, (4) eye-bolt lifting points, and (2) fork lift rails. Each eye-bolt lifting point is individually rated to support the system weight

REGULATORY COMPLIANCE

The SMART^E 5200 system is CE marked and complies with all relevant Eurpoean Directives as listed below.

Application of Council Directive

72/23/EEC (Low Voltage Directive)

Standards to which Conformity is Declared

BSEN 61010-1:2001 (LVD)

Application of Council Directive

89/336/EEC and Amending Directive 92/31/EEC

Standards to which Conformity is Declared

BSEN 61326:1998

Manufacturer Name

Aeroflex

Manufacturer Address

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Type of Equipment

Professional Laboratory RF Test Equipment

Model Number

SMART^E 5000

Serial Number

ALL

First Year of Manufacture

2006

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A passion for performance.

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Our passion for performance is defined by three attributes represented by these three icons: solution-minded, performance-driven and customer-focused.

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