Oxide Reliability Analyzer

Model RI-51

- **Selectable Temperature Ramp Control**
- **Uncompromised Oven Performance**
- **Simple, Rugged Oven Interface**
- **Guarded, Shielded Leads**
- **Accurate, Unambiguous Data**
- **Well Documented ASCII Data Files**
- **Advanced TDDB Routines**
- **PC and Tester Error Recoveries**

The RI-51 combines a fully integrated reliability test environment with excellent measurement quality and sensitivity. This makes it an ideal oxide reliability test system for process development, qualification, and monitoring.

Temperature Control

The hardware and software supplied with the RI-51 address several areas of concern regarding temperature uniformity and control:

- **Load Board Temperature Uniformity**
  The cabling for stress voltage delivery and DUT monitoring is routed through the purge hole in the thermal chamber. This is a significant improvement over alternative approaches that compromise temperature uniformity with the use of modified thermal chamber doors. The use of the purge hole cable routing technique limits the worst case load board temperature span to 1ºC.
- **Temperature Ramp Rate**
  Fast temperature ramp rates can cause thermal overshoot. Overshoot and rapid temperature changes can potentially over-stress both the device and the load board. Reedholm applications software can eliminate this problem by allowing user defined ramp rates.
- **Device Temperature Stabilization**
  Another software feature allows for a “soak time” to ensure that all devices have reached the desired temperature. After the target temperature is reported by the thermal chamber, a user specified time interval elapses before reliability testing is begun.

Access to Test Data

To ensure that data is easily accessible, the RI-51 stores all test result data in well-documented ASCII file formats. Also, the option to output the data into dBase IV format is available. Both ASCII and dBase IV files can be easily imported to many third party analysis tools, whether local or residing on a network resource.

PC Based Control and Connectivity

The entire RI-51 system is controlled by the latest generation of personal computers with memory mapped interfaces that enable communication between the computer and the instruments in less than 10µs.

Connecting the controlling computer to widely used networks and other computers (from PCs to mainframes) for use with data bases is easy. Network connectivity also provides automatic data archiving. Reedholm’s site license software policy enables a distributed reliability test environment.

Oxide Monitoring

The RI-51 provides the desired stress voltage, in parallel, to each of the devices in an experiment. A measurement cycle or scan is performed by sequentially connecting the current meter to the low terminal of each valid device remaining in an experiment. The stress power supplies provide up to 1A of stress current at up to 10V, or 100mA of stress current at up to 100V. These current limits should be sufficient to maintain the stress level even if one or more devices become shorted. If not, optional series resistors can be included. In sequence, the test algorithm:

- Periodically stresses, measures, records results, and disconnects failed samples.
- Optionally scans without storing results.
- Terminates when specified criteria are met.

Infant Scans

At the start of an experiment, two infant scans are performed, so it can be proven that all devices are functional. The first scan is done at ambient temperature. After the scan, any defective material can be replaced and the scan repeated. The failing current criteria used during the infant scans can be different than the failure criteria used later in the experiment.

Once the thermal chamber and devices have reached the final stress temperature, a second infant scan is performed. Again, the user has the option to replace failing devices and to retest.

Normal Scans

Either logarithmically, linearly, or at a user specified frequency, a scan occurs and the test results are stored. After the scan, any failed devices are disconnected from the stress supply.

"No Data" Scans

The software provides an option to perform scans in between those scans in which test results are always stored. These optional scans are termed "no data" scans. After the measured current increases above the noise threshold of the test system, results of "no data" scans can be stored when either of two possible events occurs:

- A device exceeds the failing current level.
- A user specified current increase is reached.

Failed devices are also disconnected from the stress after "no data" scans.

Post Scans

In addition to infant and normal scans, post scans can be executed after an experiment has finished. This allows data to be gathered at different temperatures and compared to the infant data. During a post scan, all devices that did not fail the infant scans are tested.

Applications Software

EMREL is the interactive software tool used to perform oxide stressing and monitoring on the RI-51. It can control up to twelve independent experiments and is used for:

- Setting up and starting experiments.
- Performing scans on active experiments.
- Viewing logs and reports.
- Creating graphical representations of results.

EMAGE, the applications software with graphical analysis capabilities, can be used to display and analyze EMREL's graphical summary reports.

Error Recovery

EMREL contains contingencies for recovery from a variety of error conditions:

- **Loss of Computer Power**
  If the computer is turned off, or when the instrumentation is being used for diagnostic testing, scans cannot be performed. Once the Reedholm shell is restarted, scans are performed on all active experiments for which a scan is either due or overdue.
- **Loss of Tester Power**
  EMREL continuously monitors the voltage stress status for each active experiment and periodically checks all hardware. If any stress supplies or matrix pins are not set correctly, EMREL suspends the associated experiment, powers down its stresses, and unhooks its matrix pins. A single attempt is made to reset the experiment. If unsuccessful, it is powered down and flagged on screen with an error message.
- **Loss of Experiment Scheduler**
  EMREL uses a file based approach to control active experiments. If either of the files is missing or corrupted, EMREL prompts the user as to whether the software should automatically rebuild the files. Once the files are rebuilt, all experiments are restarted.

Die Tracking

Another EMREL feature allows users to optionally record die information for each device so that test results can be tracked to their origin during analysis. The following information can be stored with the experiment results:

- Lot number
- Wafer number
- Die number
- X & Y location

Experiment Setup

Prior to starting an experiment, the user fills in information on an input grid, as shown in Figure 1. Along with a few optional cells at the top of the grid, the TDDB input grid contains sub-sections for the following parameters:

- **General Setup Parameters**
  The RI-51 bank number to be used for the experiment is entered along with the number of devices in the experiment. Matrix pins to be used to monitor the stress voltages on each probe card are also specified.
- **Time Parameters**
  Along with experiment duration, the initial interval and the multiplier between scans are input in this section of the grid.
- **Stress Parameters**
  Stress temperature and voltage used to accelerate the TDDB failure mechanism are input in this section of the grid. The temperature ramp rate is also included.
- **Test/Fail Parameters**
  In this section, the test voltages, delays, and failing leakage levels at stress and test voltages are entered.

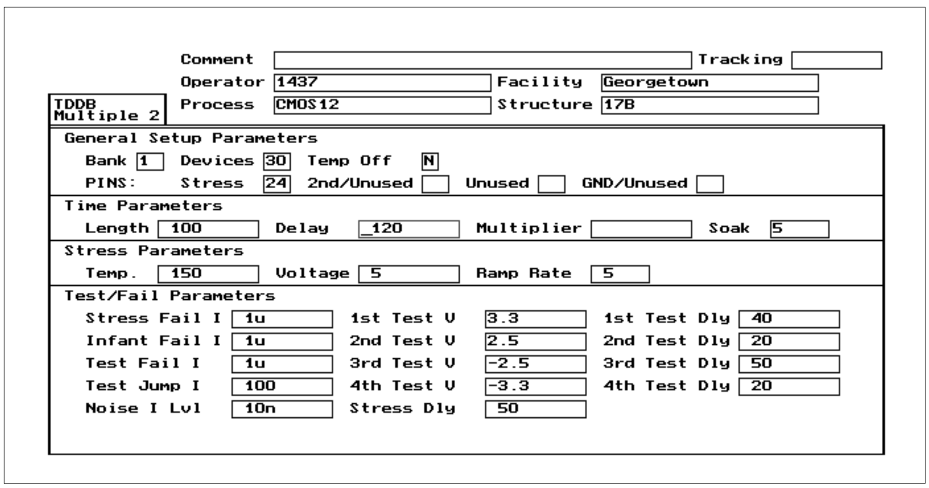


Figure 1- EMREL TDDB Input Grid

Maintenance Tools

A variety of maintenance tools is delivered with an RI-51. The main system diagnostic provides the test system user with an automatic method of verifying function and accuracy of test system modules and cable harnesses. It also offers a self-repeating, error logging tool to detect specific problems. The diagnostic software has five major components:

- Determination of tester configuration.
- Selection of modules to be tested.
- Selection of tests to be run.
- Testing for functionality and accuracy.
- Error logging summary report.

Instrument calibration is supported by a dedicated software application. Individual routines are provided for stress supplies and measurement modules. Software control allows system calibration and repair even during active experiments.

Another program is used for real-time, analog troubleshooting of the Reedholm instrumentation. This tool provides a means to connect device pins and instrumentation, to program voltages or currents, and to make measurements.

For digital troubleshooting, a program allows bit-level control and display of the instrumentation control registers. A final program furnishes instrument control procedure timing results.

System Elements

Instrument Enclosure

For a standard configuration, the RI-51 enclosure is a 7-foot, mobile rack with separate card files for switching matrix, instrumentation, and stress supplies. The test computer and printer are placed on a table adjacent to the instrumentation chassis. To accommodate the additional stress supply card files needed for the maximum configuration and/or dual stress capability, external stress chassis may be required.

Inside the test system, static power units provide dc voltages to the switching matrix and instrument backplanes. Two other components are also located within the system: an ac power control sub-system, including a control panel accessible from the front; and a power distribution box with both switched and unswitched outlets.

Switching Matrices

The architecture of the RI-51 is one in which each experiment uses a separate switching matrix bank. The banks contain from one to six cross point matrix modules (8 to 48 matrix pins). Each matrix bank can be used to test a minimum of a single device to a maximum of 46 devices. Two matrix pins in each bank are assigned to monitor the stress voltages delivered to the load boards. While the base system consists of two fully populated matrix banks, the maximum configuration can contain twelve banks.

The high quality dry reed relays used on the matrix modules provide the optimal combination of signal transmission, pin isolation, and life expectancy.

Stress Supplies

A single supply is used to stress all devices in a given experiment in parallel. Each supply is a programmable, bipolar voltage source that can provide two different stress voltages. The first option is a nominal load current of 1A at a maximum output voltage of ±10V, with respect to ground. The second option is a nominal load current of 100mA at a maximum of ±100V, with respect to ground. The analog circuitry consists of a high gain, high voltage, FET input operational amplifier followed by a power output stage. The voltage reference for the stress supply is a 16-bit precision D/A converter that outputs voltage on three different ranges, with 78µV resolution on the lowest range. A three-pole switch connects the supplies to the analog cabling. This switch allows for the accuracy enhancing feature of Kelvin sensing within a fully encompassing driven shield. Although the voltage source can supply 1A or 100mA to a load, it is fully protected against indefinite output short circuits.

When using the ±100V stress option, a set of current limiting resistors can be used so that the stress supplies do not reach current compliance when devices fail.

Measurement Instrumentation

Devices are measured in sequence using a single digital multimeter. Current is measured using an active metering technique that provides almost zero voltage burden while measuring currents up to ±200mA. This means that the meter can be assumed to be an ideal zero-ohm and zero-volt short on each of the eight current ranges until current limiting occurs.

The meter uses a monolithic, 16-bit sampling, A/D converter based on a successive approximation algorithm. During system initialization, a self-linearizing calibration routine automatically executes and produces full 16-bit linearity. For maximum sensitivity, the digital averaging feature of the low level instrument drivers provides repeatable sensitivities of ±2pA.

In addition to the digital meter, a programmable voltage and current source is provided so that system self-tests may be performed.

Analog Cabling

Fully guarded and shielded cabling connects the pins in the switching matrix to a rugged bracket mounted on the thermal chamber door. At both ends of the cabling, zero insertion force connectors provide quick and easy connections as well as excellent reliability. Routed through the thermal chamber's purge hole, high temperature analog cabling attaches to the load board card edge connectors.

Thermal Chambers/Load Boards

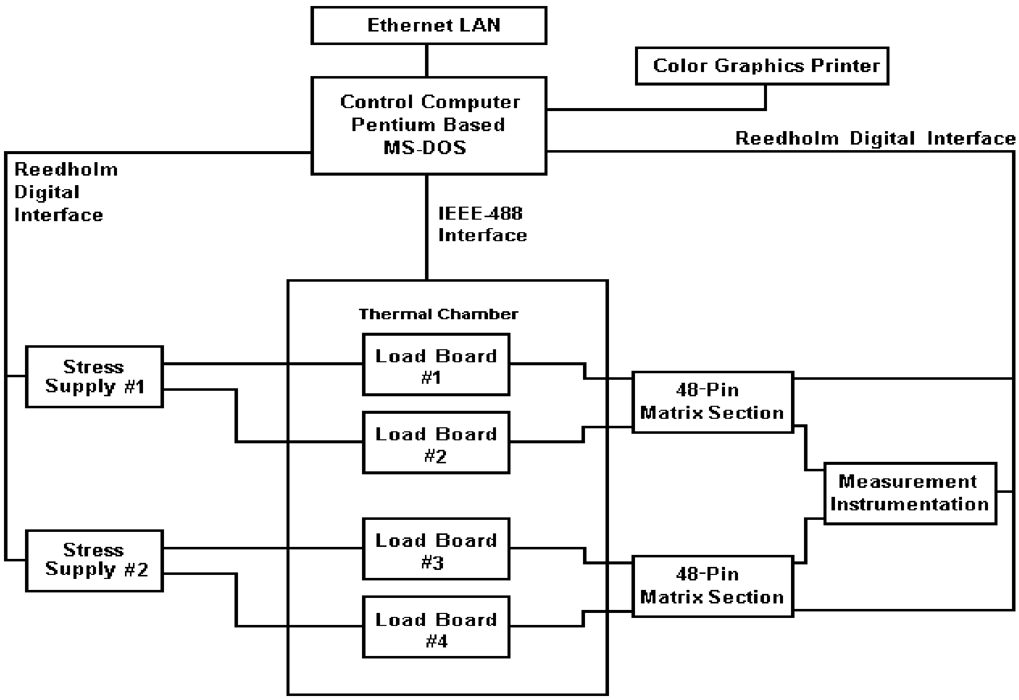
The RI-51 is delivered with the thermal chamber(s) to be used with the system. Hardware integration includes design of the internal and external mounting brackets for the analog cables and load boards. While originally two experiments share a single chamber, other combinations are possible.

Reedholm also supplies load boards to be used with the RI-51. Up to 23 devices can be stressed on each board. In cases where a customer's packages do not match Reedholm's load boards, alternative solutions can be explored. Diagnostic load boards are provided for verification of the signal pathways all the way to the load board(s).

Wafer Level Test Option

With an expansion of the switching matrix and the inclusion of additional instrumentation and software, it is possible for the RI-51 to perform wafer level testing. Whether for automated process control, engineering analysis, wafer level reliability, and/or device characterization, all of Reedholm's standard applications can be performed on an upgraded RI-51.

RI-51 System Block Diagram



Base Configuration Shown:
- (2) 46 Device Experiments
- (4) Load Boards
- (1) Thermal Chamber
- (92) Total DUT

Maximum Configuration:
- (12) 46 Device Experiments
- (24) Load Boards
- (6) Thermal Chambers
- (552) Total DUT

Base System Configuration

Instrument Enclosure
Floor Standing Dimensions:
L24" x W36" x H84"
L610mm x W914mm x H2134mm
Switching Instrument Supplies
(3) Backplane Assemblies
(2) Tester Analog Cables

Tester Computer
Check with factory for present model

Color Printer
Check with factory for present model

Stress Instrumentation
(2) VSM, Voltage Stress Modules

Test Instrumentation
(1) DMM, 16-Bit Digital Multimeter
(1) VFIF, Voltage/Current Forcing Module

Matrix
(12) Crosspoint Matrix Modules (96 Pins)
(1) Node Extender Module
(2) Node Terminator Modules
(2) 7.5' Oven Analog Cables
(1) 9" High Temperature Analog Cable

Thermal Chamber
(1) Sun Systems, Model EC01 (200 C)

Load Boards
(4) Four Layer Load Boards (23 DUT each)
(4) Diagnostic Load Boards

Handling Data

Whether experiments are in progress or complete, information is available in the form of logs, reports, and summaries. Figure 2 exemplifies a graphical output.

- **Logs**
  A sequential log of each experiment contains dates and times of start-up, completion, and the time each scan is taken. Any other pertinent information is also recorded in the log.
- **Reports**
  Each report consists of a header describing the experiment and set-up conditions followed by information for each data scan. For every scan, the following data is shown: scan number, elapsed time, number of devices failed, percentage of devices failed, and temperature.

  Conveniently, reports can be displayed on the monitor or sent to the printer. They can also be sent to the hard disk for later retrieval. Reports can include data from either individual devices or all devices in an experiment. Another option allows viewing of results from only the first scan and last valid scan for each device.
- **Summaries**
  Text and graphical summary information can be generated. Any text editor can be used to view the text table files, while Reedholm's EMAGE software enables viewing of the graphical outputs. The TDDB tables include failures sorted by both t_{BD} and Q_{BD}, which are shown versus cumulative percent and normalized.

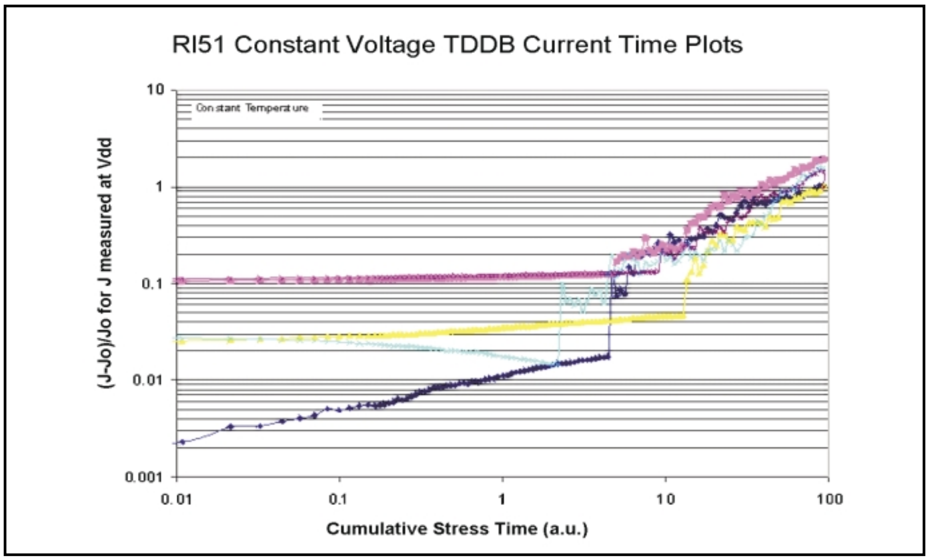


Figure 2 - Constant Voltage TDDB Results

Support

Warranty

Each system comes with a 12–month factory warranty for defective parts and labor. Additionally, extended warranty and service contracts are available.

User Training

Training on the use of diagnostic and applications programs can occur at the factory or on site during installation. The class covers experiment control, data analysis, and system maintenance.

Documentation

Complete documentation delivered with the test system includes comprehensive user's manuals describing hardware and software along with schematics of system elements.

Application Support

Technical phone and e-mail support is available from the U.S. Monday through Friday, excluding holidays. Contact us by

- Phone: (512) 876-2263
- e-mail: support@reedholmsystems.com

Local technical support from Reedholm's distributors is also available in many parts of the world.

Specifications

Use Conditions

Temperature: 18º–28ºC

Humidity: 10%–60% R.H. Non-Condensing

Nominal Power:

System—120V, 50/60Hz

Thermal Chamber—240V, 50/60Hz

Switching System

The switching sub-system is a critical element of a dc reliability test system. Reedholm has taken special care to develop low noise, high performance matrix switching modules. Hazard detection software prevents “hot” switching of relays, thereby maximizing the operational life of the relays.

Maximum Stand-off Voltage	±600V
Maximum Carrying Current	±2A
Pin-to-Pin Leakage (At 100V guarded)	<±10pA
Pin-to-Pin Leakage (At 100V unguarded)	<±1nA
Pin-to-Pin Thermal EMF	<±10μV
Pin-to-Pin Resistance (Shorted)	<500mΩ
Switching Speed (Including Software Delay)	1ms

Voltage Stress Module (VSM)

Mode	Range	Source Error		Resolution
		Offset	% of Value	
Low Voltage Configuration Only				
Voltage	2.5V	2.5mV	0.05	78.125μV
	5V	5mV	0.05	156.25μV
	10V	10mV	0.05	312.5μV
High Voltage Configuration Only				
Voltage	25V	25mV	0.05	781.25mV
	50V	50mV	0.05	1.5625mV
	100V	100mV	0.05	3.125mV

Notes:
1. Accuracy of voltage forced on a given range is equal to the sum of a percentage of value forced and an offset error: value ± (% of value error + offset error).
For example, forcing 1V on 2.5V range:
1V ±(0.05% of 1V + 2.5mV)
1V ± 3mV

Digital Multimeter (DMM) Module

Mode	Range	Measure Error		Resolution
		Offset	% of Value	
Voltage	250mV	250 V (50μV)	0.03	7.8125μV
	500mV	250μV (50μV)	0.03	15.625μV
	1V	300μV (75μV)	0.03	31.25μV
	2.5V	500μV (100μV)	0.03	78.125μV
	5V	1mV (2mV)	0.03	156.25μV
	10V	2mV (4mV)	0.03	312.5μV
	25V	5mV (1mV)	0.03	781.25μA
	50V	10mV (2mV)	0.03	1.5625mV
	100V	20mV (4mV)	0.03	3.125mV
Current	100nA	100pA*	0.20	3.125pA
	1μA	300pA*	0.15	31.25pA
	10μA	2nA	0.05	312.5pA
	100μA	20nA	0.05	3.125nA
	1mA	200nA	0.05	31.25nA
	10mA	2μA	0.05	312.5nA
	100mA	20μA	0.05	3.125μA
	1A	200μA	0.10	31.25μA

Notes:
1. Maximum output current on 1A range is ±200mA. On the other ranges, the maximum is 125% of range.
2. Settling time to 0.01%: 4.0ms, 100nA range
2.3ms, 1μA range
1.7ms, 10μA-1A ranges
3. CMRR Current: <1ppm of range per volt, 10μA-1A
<2ppm of range per volt, 1μA
<6ppm of range per volt, 100nA
*4. Accuracy on the lowest three current ranges is determined with digital averaging approximating line cycle integration.
5. Accuracy of current measured on a given range is proportional to range error and a percentage of current being measured. For example, measuring 50μA on the 100μA range would have uncertainty of 50μA ±(20nA + 0.05% of 50μA) = 50μA ± 45nA.
6. When measuring currents form sources with non-zero conductance, add the following amounts to the error specification:
±(830ppm of value + 151pA)/mho.

Expected Performance

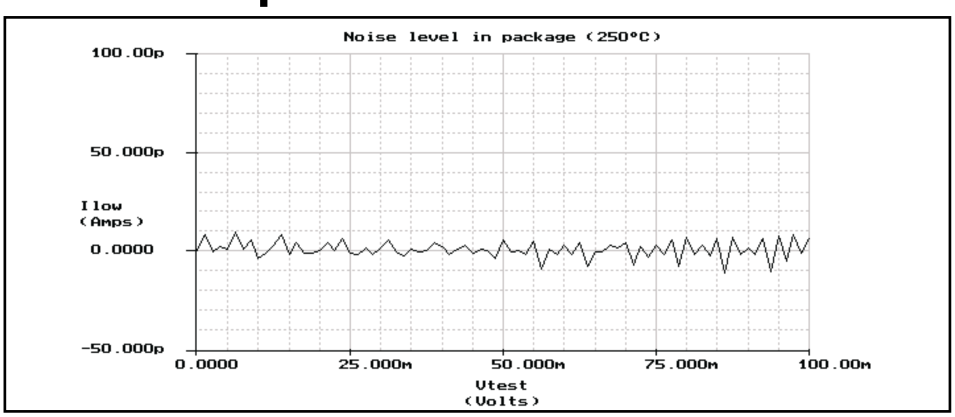


Figure 3 - System Noise Including Load Board and Oven