TTS-1000

Thermal Test System

The *TTS-1000* thermal test systems combines the test and measurement capability of dedicated instruments with the ease of operation and data collecting capability offered by graphical-user-interface-driven software operating on an integrated computer. This unique combination provides the following features and benefits:

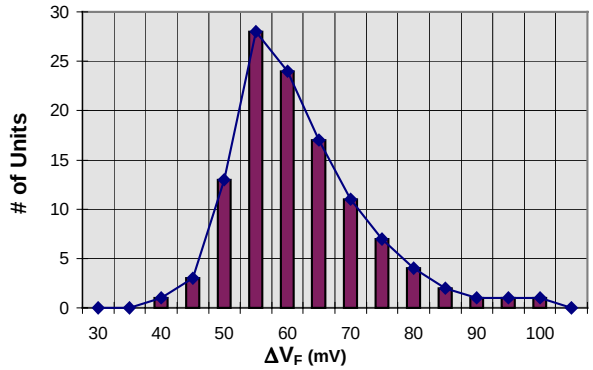
- Accurate implementation of the Electrical Test Method for Thermal Resistance Measurements of Diodes - Conforms to Mil-Std 750 Method 3101 thermal test method
- Automated Thermal Measurement Operation for Heating Curve and Cooling Curve data collection, reduction and graphical presentation
- Multi-Mode operation for:
  - Single-shot **Manual**
  - **Automatic** Heating and Cooling Curve Generation
  - **Sequential** tests for measurement of a single device under multiple conditions, including automatic control of thermal test environment between tests
- Kelvin Contact configuration for precise power dissipation forcing and accurate temperature measurement
- Windows -based, integrated computer capable of controlling other equipment for automation of thermal environmental conditions - available in optional software version
- Mouse-driven graphical user interface simplifies test program creation, editing and storage
- Graphical data presentation on screen display and hardcopy printout
- Built-in compatibility with RS-232C, IEEE-488, SECS II and network interfaces - available as plug-in options
- Built-in power supplies and switching circuitry optimized for proper testing and minimal potential device damage
- Different control modes ("Engineer" & "Operator") insure test program and data security
- Extended Heating Time range for Thermal Transient (Die-Attachment and Thermal Response) Testing and Thermal Resistance (θ_{JC}, θ_{JA}, Ψ_{JT}, etc.) measurements
- Integrated 8-channel Thermocouple Measurement Capability for monitoring case, lead and/or environment temperatures - available as plug-in option

Thermal Data Made Simple ---

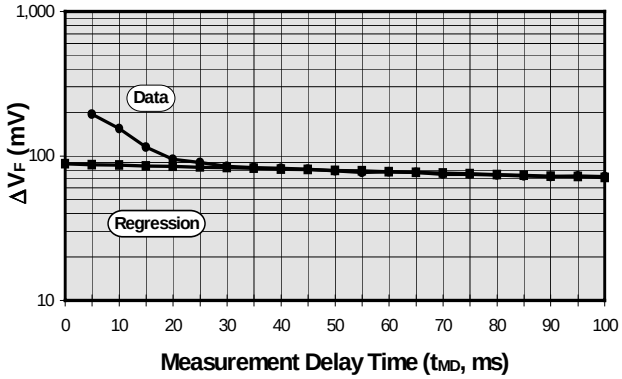
TABULAR DATA LISTING

Test #	DUT #	t_H (ms)	ΔV_F (mV)	θ_{JX} (°C/W)	ΔT_J (°C)	CU (mV/A)	I_H (A)	Temp i (°C)	Temp f (°C)	Bin #
1	1	300	27	17.9	13.5	179	0.151	23.7	23.7	1
1	2	300	28	18.3	14.0	183	0.153	23.7	23.7	1
1	3	300	27	17.5	13.5	175	0.154	23.7	23.7	1
1	4	300	29	19.2	14.5	192	0.151	23.7	23.7	2
1	5	300	25	16.4	12.5	164	0.152	23.7	23.7	1
1	6	300	27	17.6	13.5	176	0.153	23.7	23.7	1
1	7	300	28	18.4	14.0	184	0.152	23.7	23.7	1
1	8	300	27	17.9	13.5	179	0.151	23.7	23.7	1

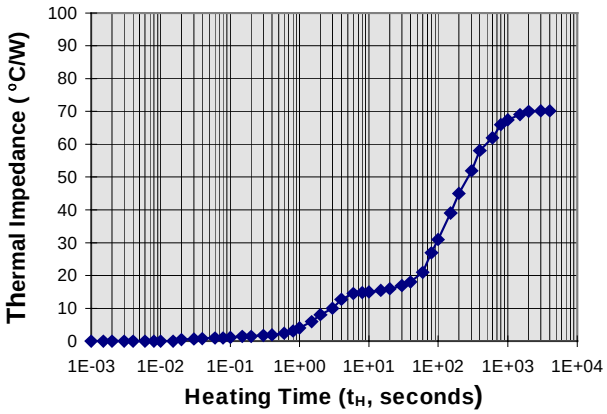
HISTOGRAM



COOLING CURVE



HEATING CURVE



Tabular Data Presentation

In screen display, hardcopy output or disk file, this format provides all the data collected in a simple to use manner. The screen display allows the user to see the data as it is collected. When testing is completed, the same data can be printed out for archival and analysis purposes. The disk file, in comma delimited ASCII format, is available for archival purposes or for import to the user's favorite data base, spreadsheet or analysis software.

Histograms for Production /Engineering Testing

When testing for a single data results, as in thermal response (die attach evaluation) or θ_{JC} measurements, depressing a single key allows the user to switch from a tabular listing to a histogram graphical display with statistical information (average, median, mode and standard deviation) shown in text form.

Cooling Curve for Test Setup and Data Correction

The automatic generation of Cooling Curve data and graph display simplify the task of accounting for junction cooling effects. The graph display includes a user-controlled best-fit straight line algorithm for zero Measurement Delay Time determination and, if enabled by the user, automatic on-line data correction to further enhance the data measurement accuracy. From either display, another key stroke produces a hardcopy printout of the displayed information.

Heating Curve for Device Thermal Characterization

The automatic generation of Heating Curve data and graphical display allows the user to fully thermally characterize a device for the given thermal environment of the test setup. Analysis of this curve provides the user with significant thermal information on the device's thermal structure and allows the user to pick the appropriate Heating Time for specific measurement purposes. A single key stroke switches the display from a tabular data listing to the graphical curve. From either display, another key stroke produces a hardcopy printout of the displayed information.

What to look for in a Thermal Test System ---

TEST FEATURES:

With over 25 years service to the thermal test market, *TEA* has incorporated into the *TTS-1000* the key features that users need --

- ⇒ Carefully designed integrated testers dedicated to the proper thermal testing of devices with built-in device, system and operator protection - not a computer with general-purpose plug-in cards and external power supplies
- ⇒ Test automation for the most commonly required test types, with flexibility to perform "custom" tests as required - not limited to perceived notations of data interpretation or presentation
- ⇒ Strict conformance to existing and proposed military and industry test method standards to insure the generation of accurate and comparable data

While competitors concentrate on fancy software to dazzle the user, *TEA*'s goal is to assist the user in collecting the best data possible in a simple, proven manner.

"ALL IN ONE" IS NOT ALL GOOD:

Thermal testing is usually done in two parts. First, the temperature sensitive parameter (TSP) is calibrated so that the relationship between temperature and diode voltage is accurately known. Experience has shown, and the test method standards recommend, that the calibration is best performed on a batch of devices - not one at a time. *TEA* offers a separate low-cost instrument for this purpose. Second, after the calibration, the devices are individually tested on the *TTS-1000* system for thermal response and thermal resistance. This two step partitioning allows for greater equipment utilization and reduced overall test time.

DEDICATED APPROACH

Using its long history of working with semiconductor devices, *TEA*'s line of thermal parametric test systems have be designed for specific testing requirements over a wide enough dynamic range to accommodate most requirements. Designing systems for specific dynamic ranges allows for more optimum circuitry to increase measurement accuracy, to maximize device-under-test protection and to greatly simplify system operation. So called "expandable" systems offered by competitors have built-in trade-offs that put the burden of tester integration and operation on the user and often do not adequately address very specific testing requirements of certain semiconductor devices.

MEASUREMENT ACCURACY AND FLEXIBILITY

TEA's *TTS-1000* measurement circuitry has been optimized for the difficult task of accurately determining small voltage difference on top of large voltage signals at high speed. Software algorithms for digital filtering augment the hardware's inherent capability to insure accurate data results. The user interface software for system control, data collection, and data presentation has been designed for greatest user flexibility without sacrificing ease of use. While capable of providing all collected data in tabular or graphical form, the software also allows the user to restrict the display so that only certain parameters are presented on the screen or printed to the system's printer.

INSTRUMENTATION ARCHITECTURE

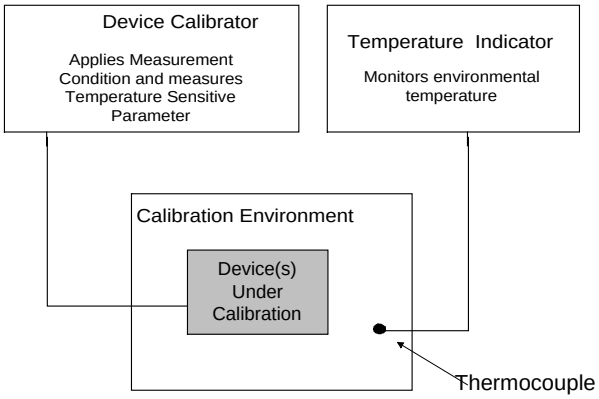
The ***TTS-1000*** architecture is instrumentation based and includes multiple microprocessors for dedicated control of specific functions. This approach enables optimized design for the critical measurement and forcing functions while allowing the built-in computer to act as a master controller, data manipulator and the interface to the user. All timing functions are referenced to a microprocessor-controlled crystal oscillator.

THERMAL MEASUREMENT ACCESSORIES

TEA offers a full line of accessory products to simplify the thermal measurement/test process. Whether for engineering characterization or production testing, test fixtures are offered for most standard discrete and integrated circuit package styles in ambient (still-air), moving air, liquid and heat sink environments. Statistical Process Control software is available for engineering and production data analysis.

How to set up a Thermal Test Capability ---

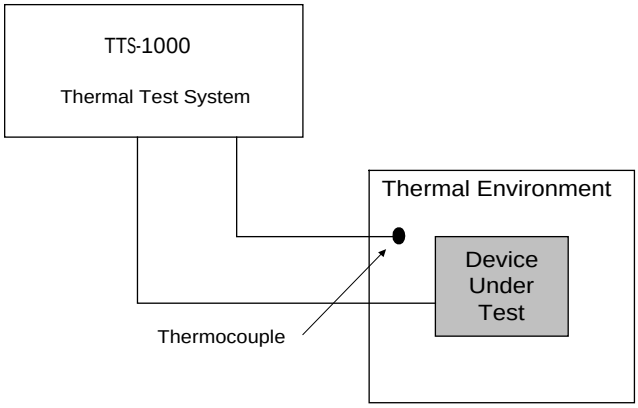
Calibration Setup



TEA supplies an integrated instrument (*TCS-100*) for determining the relationship between the temperature sensing voltage and the junction temperature in accordance with the requirements of Mil Std 883 Method 3101. This instrument has contains the precision constant current supply for the Measurement Current (I_M), a digital voltmeter for TSP Forward Voltage (V_F) measurement, and a thermocouple measurement circuit with 0.1 °C resolution and 2% or better accuracy. The thermocouple is used to monitor the Calibration Environment Temperature. Device calibration is typically done in devices batches of 10 or 12 units. The thermocouple is usually attached to the case of the center device.

Usual practice is to use a small oven for batch testing of several devices. A liquid bath is often used for calibration of single devices.

Thermal Measurement Setup



The integrated *TTS-1000* System contains everything needed for making thermal measurements. Hard copy of raw data, test programs, tabular data and data in graphical form is available from the printer supplied with the system.

The thermal environment, whether it be just an electrical contact fixture for thermal transient measurements (i.e. thermal response, die attachment evaluation, etc.), still-air chamber for θ_{JA}-type measurements, moving-air wind tunnel for θ_{JMA}-type measurements, or heat sink for θ_{JC}-type measurements, connects directly to the system. The system's built-in thermocouple circuitry provides real-time measurement of the thermal environment temperature. The thermo-couple data can be used for automatic correction of the device thermal data in certain circumstances to further improve the device thermal data accuracy and to calculate Ψ_{JT} as well.

TEA offers a broad range of different thermal test fixtures and environments for handling most standard semiconductor package styles. Custom-designed fixtures and environments are available for special, non-standard package styles and thermal environments.

Thermal Measurement Systems that make Sense ---

TEA offers the *TTS-1000* System configured to suite various thermal testing requirements of diode devices (or devices tested as diodes) without purchasing more capability than needed.

	TTS-1000	Options/Comments
Device Capability		
	PN, Schottky, LED and Laser Junction Diodes	
Heating Conditions	**Specification**	**Comments/Accuracy**
Heating Time (t_H) Range	1 ms to 5,000 sec	
Heating Time (t_H) Seeting	Manual – Single t_H value Automatic Curve Modes - Single t_H end value	Cooling Curve Mode collects data for t_{MD} varying from 5 µs to 100 µs in 5 µs steps for a fixed t_H setting Heating Curve Mode collects data at rate of 7 points per time decade from 1 ms to set t_H end point
Number of Heating Supplies	1	
Heating Current (I_H) Supply Setting	0.01 to 10 A, 10 mA steps 1 mA to 1.0 A, 1 mA steps	±0.1% of setting ±5 mA ±0.1% of setting ±0.5 mA
Heating Voltage (V_H) Compliance	up to 5 V	
Supply Configuration	negative at system ground	
Measurement Conditions		
Number of TSP channels	1	
Type	4-wire Kelvin	
Measurement Current Setting	1.0 to 100 mA	±0.1% of setting ±0.02 mA
Measurement Delay Time Setting	5 to 100 µs, 1 µs steps	
K Factor Setting	0 to 1 °C/mV	
Thermocouple Measurement		
Number of Thermocouple channels	4	
Thermocouple type	T	
Measurement Data Available		
TSP Voltage Change (ΔV_F)	399.9 mV (max)	±0.025% of fs ±0.1 mV
Thermal Resistance (θ_{JX} or Ψ_{JT})	499.9 °C/W (max)* 49.99 °C/W (max)*	±0.025% of fs ±0.2 °C/W ±0.025% of fs ±0.02 °C/W (* automatic range switching)
Heating Voltage (V_H)	4.999 V (max)	±0.1% of fs ±2 mV
Junction Temp Change (ΔT_J)	199.9 °C (max)	±0.05% of fs ±0.1 °C
Comparison Unit (CU)	9999 mV/A (max)	±0.12% of fs ±1 mV/V
Thermocouple Temp (T)	199.9 °C (max)	±0.05% of fs ±0.5 °C

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