National Institute of Standards & Technology

Specifications

Standard Reference Instrument Series 6002

Thin-Film Multijunction Thermal Converter

Description: The most accurate ac voltage measurements are made by comparing the heating effect of an unknown ac signal to that of a dc reference using devices known as thermal converters. In its most basic form, thermal converters consist of a thermocouple placed at the midpoint of a heater structure, commonly a thin wire. These devices are extremely broadband, with a frequency range from 10 Hz to more than 100 MHz, and generally have input voltages limited to a few volts. The quantity of interest, called the ac-dc difference, can be nearly zero at audio frequency, but may be as large as several percent at 100 MHz.

The most accurate thermal converters, called multijunction thermal converters (MJTCs) consist of multiple thermocouples arrayed along a heater structure. Modern MJTCs are made using semiconductor fabrication techniques, resulting in thin-film MJTCs. These devices are in common use at National Metrology Institutes (NMIs) where they form the international basis of ac voltage and current metrology. Thin-film MJTCs fabricated on glassy substrates have the same broadband characteristics as traditional thermal converters, but have larger dynamic ranges and smaller ac-dc differences at varying input voltages or currents (voltage coefficients). MJTCs are also expected to have smaller ac-dc differences than traditional thermal converters because their design results in smaller thermoelectric errors.

Although the performance of thin-film MJTCs is better than traditional thermal converters, they are not generally available to the metrology community. With the release of thin-film MJTCs as Standard Reference Instruments, NIST is making this technology available to the ac user community.

Design: The MJTCs developed as Standard Reference Instruments are of the bifilar type, fabricated on substrates of fused silica, and bonded to Al_2O_3 carriers. Each device is equipped with a cover to protect the die and wire bonds. They are identical to standards used in the AC-DC Difference Project at NIST.

Voltage/Frequency Ranges: The MJTCs will be supplied mounted in an enclosure with appropriate input/output connectors, and with a minimal calibration report covering the following ranges:

- 1 V at 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz, 100 MHz
- 3 V at 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz, 100 MHz
- 5 V at 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 10 MHz, 100 MHz

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Report Issue Date: 12 December 2022
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Hazardous Material: These MJTCs contain no hazardous material.

Standard Configurations

6002a Thin-Film Multijunction Thermal Converter
Nominal input resistance 600 Ω ± 1 Ω

6002b Thin-Film Multijunction Thermal Converter
Nominal input resistance 1040 Ω ± 2 Ω.

Output Resistance: The MJTCs will be supplied with output resistance less than 30 kΩ.

AC-DC Difference: The MJTCs will be warranted to have ac-dc differences of less than 25 μV/V in the frequency range from 10 Hz to 1 MHz, and less than 0.5 % at 100 MHz. For NIST uncertainties at these points, see https://shop.nist.gov/ccrz__ProductList?categoryId=a0lt00000013aDsAAI&cclcl=en_US.

Calibration Report: A report giving the ac-dc differences and uncertainties of the MJTCs will be included with the MJTC. Calibration at points other than those listed above will be made according to the NIST fee schedule at https://shop.nist.gov.

NOTE: As the technology improves and new MJTC designs are available, NIST reserves the right to alter quantities such as the input/output resistance.

Delivery and Shipping: Delivery will be through the NIST Office of Reference Materials (https://shop.nist.gov/). Shipping costs will be provided in the quote. Customers are responsible for all customs duties and import fees (HTC 9030.33.0040).

Support: Although not prone to failure, and although more robust than traditional thermal converters, like any instrument an MJTC may fail due to input signals exceeding its maximum rated input amplitude. MJTCs that fail may be returned to NIST for a postmortem. If no failure mechanism can be determined or if there are signs of manufacturing defects, the MJTC will be replaced free of charge. If, however, there is clear evidence of failure due to over-ranging the input, the MJTC will not be replaced free of charge.

Unit description: The MJTC will be mounted in an enclosure with appropriate connectors and delivered with a calibration report at the points described above.

REFERENCES

[1] Lipe, T. E.; Kinard, J.R.; Novotny, D.B.; Sims, J.S.; *Advanced Sensors for Accurate, Broadband AC Voltage Metrology;* J. Phys.: Conf. Ser., Vol. 450, p. 012036 (2013).

[2] Lipe, T. E.; Kinard, J.R.; Novotny, D.B.; Sims, J.S.; *Advanced Thermal Sensors for Broadband AC Voltage Metrology*, NCSLI Measure J. Meas. Sci.; Vol. 9, pp. 74-78 (2014).

Report Revision History: 12 December 2022 (Editorial changes); **28 April 2016** (Original report date).

Users of this SRI should ensure that the Specifications Report in their possession is current. This can be accomplished by contacting the Standard Reference Instrument Program Office: telephone (301) 975-2200; e-mail srminfo@nist.gov; or via the Internet at https://www.nist.gov/sri.