
# NEW CALIBRATION SYSTEM FOR THE "E-MAQS" TEMPERATURE MEASURING SYSTEM

## THE TASK

The "E-MAqS" temperature measuring system has been successfully used for various procedures in laser material processing for more than ten years. In comparison with a conventional pyrometric solution, this system offers enormous improvements in process control and guidance, mainly in laser hardening and buildup welding.

Precise measurement of the surface temperature is the basis for optimal process control. It requires exact system calibration to be performed by the user on site because the "E-MAqS" system can be used flexibly and depending on the application. For this purpose, a simple, small and function-adapted calibrating radiation emitter is required. A classical black radiator is too complicated for applications in industry and is also fault-prone.

The intuitive operation of the specific radiator should be controllable both manually and by PC software. Some customers even demand triggering per remote maintenance via Internet, since calibration can thus be offered as a low-cost service worldwide. A self-diagnosis function for automated detection of system or fault states and their representation is also desirable.

## OUR SOLUTION

The functional core of the IWS system is a high-power LED array with an optical initial power of 1 W. This LED array irradiates a diffusor disk in a narrow wavelength range, and the disk is limited by a mechanical aperture. The temperature measurement system "E-MAqS" to be calibrated uses the identical narrowband range of the electromagnetic spectrum for temperature measurement.

A programmable current generator is used as the driver stage for the LED array. This integrated circuit is triggered via a bus interface and makes possible current changes with 0.3 mA resolution over a setting range of 600 mA. The master module of this communication is an advanced microprocessor with many communication interfaces. The microprocessor not only makes it possible to communicate with the sensors, but also includes field bus interfaces and provides an adequate Ethernet and thus Internet connection.

A specially adapted highly integrated printed circuit with low space requirements and weight, low susceptibility to faults and optimal energy consumption was developed (Fig. 1). The basic functions are enhanced by circuit functions for self-diagnotics. This way, relevant parameters, such as power, temperature or maximal current and voltage are constantly monitored. Ageing processes, damage to the LED array or other circuit components, and faulty operations can be detected reliably.

The user is informed of the regular calibration cycles by a highly precise real-time clock, while error messages are assigned a timestamp. A position and an acceleration sensor that function as integrated spirit levels, or an angulometer, are additionally installed. An advanced graphic touch screen with intuitive menu guidance functions serves as the human-machine interface (HMI).


2

## RESULTS

The LED array at the IWS is calibrated in a temperature range from 800 ° to 1450 °C to the standard of the National Metrology Institute of Germany and is designed as a customized calibrating device for the "E-MAqS" temperature measuring system developed at the IWS. All calibration data are immediately stored by the relevant sensor. Maloperations through loading and use of incorrect calibration data by the user are excluded.

The high power LED array is switched on automatically just for the calibration measurements lasting a few seconds. This prevents ageing of the components, is energy-efficient and allows energy to be supplied by the 24 V connector socket, battery or power-over-Ethernet. The calibration irradiator can be monitored and the calibration itself can be performed by remote maintenance. The system user is responsible for the mechanical setup of all components. After remote access to the network of the respective equipment and single systems, calibration can be performed as a service or, together with the customer, in the form of training. The individual calibration projects are managed via a software module.

The recording of two suitable characteristic lines is sufficient for complete calibration of an "E-MAqS" temperature sensor. A factor describing the specific properties of each configuration, such as aperture, exposure time, binning mode of the camera, as well as measuring distance, attenuation (damping) of the laser optical components and many other influences, may be calculated according to Planck's radiation law. Except for the gray value signal of the camera and the temperature, the mathematical relationship consists only of simple or natural constants. Having found the factor, all the other characteristic lines can be exactly calculated for any arbitrary temperature range.

During a measurement, within a few microseconds, the measuring range of the "E-MAqS" temperature measuring system can be switched, and the exact temperature can be calculated as a function of the measurement and camera parameters. Precise temperature calculations well beyond the calibration range can be performed by means of the exact timer components of the camera. For high temperature processes, temperature measurements can be carried out at 3000 °C with minimal measuring errors. Characteristic curves calculated this way are generated by the software automatically and stored in a format compatible with the control software.

For precise calibration, as wide as possible a perpendicular radiation of the "E-MAqS" systems should be addressed by the calibration irradiator. The angular error should not exceed +/-3 ° ; this requirement can be met easily even in the industrial environment by means of the integrated location sensors and spirit levels.

The different housing shapes of the irradiator were 3D printed. This technology makes possible robust and flexible mechanical designs, both as a portable device and machine component with stationary installation (see Fig. 2).

*1 Contact wafer of the LED array for temperature calibration*

*2 Housing design, housing 3D printed*

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