Signal Processing of Pyroelectric Arrays for Industrial Laser Applications

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Pyroelectric arrays are widely used for detection of UV-VIS and IR radiation. For their derivative sensor characteristic with respect to temperature their application is addressed to modulated and impulsive radiation. Also for this type of sensors, novel applications require detailed process study and custom signal processing.

For whichever industrial laser application, source diagnostic (temporal waveform, peak amplitude and beam pointing stability, divergence, power density mapping) is claimed, especially for the most involved parameters which determine the efficiency of the process.

Continuos Wave CO_2 laser systems used for cutting metal slabs have long tube arms of large section (5 cm diameter) with knobs supporting mirrors which necessitate to be aligned. To this aim the authors developed large area ($5 \times 5\,\mathrm{cm}^2$) 8×8 elements matrix arrays for a detailed evaluation of the laser spot inside the arm section and its centroid determination. As laser bursts of duration and delay depending on power are currently used for the alignment, we processed the sensor signal for the attainment of the temporal waveforms first of all. Due to the coherence of the laser source one array element is sufficient to diagnostic the laser temporal waveform for source diagnostic. Improved temporal resolution was obtained with special filters extending the flat response region of the sensor bandwidth to higher frequencies. We analysed the bursts and registered the time characteristic of CW regime attainment after the initial transient.

The signals from the matrix arrays were processed after this time by an ACF2101 Burr Brown (switched dual integrator) with *sample* & *hold* function synchronized for all array elements. The front-end analog electronics is formed by 64 dual integrators which, together with the sensors array, constitute the whole device that is fixed at the laser system arm sections. The integrated signals were A/D converted with 10 bits by an Hitachi 32 bit microcontroller equipped with 8 input ports switched by a multiplexer 1 to 8 in a separate device connected to the sensor head. In the electronic design, we optimised the degree of insulation in the hold phase, and we performed the evaluation of the off-set voltages and their influence both on the intensity distribution and the beam spot centroid determination. The first goal was reached by inserting a resistance in parallel with each element and an insulation better than 1% (corresponding to a current two order of magnitude lower than the maximum pyroelectric current).

The signal processing allows for matrix calibration trough normalisation of all the elements responses to the highest value measured in a preliminary calibration phase with a laser of high stability. Owing to the measured linearity in a wide power range (up to 1.5 kW) and different times integration (4–100) ms, the processing allows the choice of the proper time integration for better signal-to-noise ratios with different laser powers. The off-set voltages contributing with noise to an integrated signal also without laser bursts were suppressed by reciprocal subtraction of two-without and with laser burst- sequential acquisitions. Stability of centroid estimation of the order of 0.5 mm has been achieved with 1.5 kW CW Laser in industrial environment.