Abstract

Contemporary industrial automation systems and transmission infrastructure impose particularly high requirements on the reliability and durability of electrical connectors. M12 connectors, widely used in applications exposed to demanding environmental conditions, represent a critical element determining the functional stability of such systems. Consequently, it is essential to conduct comprehensive investigations that evaluate their mechanical, electrical, and material properties under conditions reflecting real operational scenarios.

This dissertation presents an integrated analysis comprising a pull-out strength test in accordance with DIN EN 60352-2, a 100-cycle mating and unmating test with resistance measurements taken every five cycles, and contact resistance assessments using the four-wire (Kelvin) method, supplemented by accelerated aging tests (85/85 + thermal shocks). Particular attention was paid to the influence of crimp geometry and the type of galvanic coating (gold, silver, tin, or uncoated) on the long-term stability of the connectors.

A key contribution of this work is the development of an original decision-making algorithm based on a point-scoring model with a flexible weighting system for partial parameters, enabling dynamic classification of connector quality according to the specific application scenario. The algorithm, extended with a logistic regression model, allows predictive evaluation of quality parameters and determination of threshold values with a defined confidence level. This solution represents a novel approach with significant practical potential, integrating classical test methods with data analytics and machine learning tools for production quality control systems.

The originality of this dissertation lies in the combination of standard normative tests with an innovative algorithmic approach, which not only enhances the methodology for assessing electrical connectors but also provides a tool with direct practical relevance for industry.