

## Introduction of the LMK Position

The LMK Position system from TechnoTeam Bildverarbeitung GmbH combines robot-guided machine vision with high-precision luminance and color measurements by combining the LMK series with the high-precision robotic systems from DENSO Robotics. The LMK Position system is an excellent way to perform efficient and effective measurements for complex or time-consuming alignment tasks where speed and precision requirements are of the essence.

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*LMK Position: High-precision geometrical reproducibility at high-speed  
High flexibility in a compact setup*

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*Figure 1: TechnoTeam's solution for complex alignment: Fast and easy-to-use vision-based robotic*

In this application note, we focus on the integration and safety aspects of the LMK Position. You will learn what safety measures are applied and how we ensure a safe operation for both your operators and all equipment involved.

### Software and hardware requirements

The LMK Position is compatible with the LMK5 and LMK6 photometer/colorimeter model type series and all manual standard, AR/VR, macroscopic lenses, a conoscopic lens, and several standard autofocus lenses. Further, an ActiveX-enabled LabSoft with a release date after 2021 is required.

## Advanced safety concept: Three-level approach

The safety of your employees and your equipment comes first. This includes the mandatory installation of

- One or several emergency buttons (directly at the robot controller)
- Door switches and/or light curtains to ensure that no automatic movement is possible if a person is near the system (directly at the robot controller)

Further, TechnoTeam has put much effort into optimizing safety for humans and equipment. Each LMK Position system comes with the following additional safety options:

- The “Robot Position Monitoring” option from DENSO ensures that the robot, including the LMK and the lens, will not leave a predefined virtual box (directly at the robot controller). This option was certified by TÜV Rheinland to be safe for humans (Figure 15 Left)
- The “Robot Speed Monitoring” feature from DENSO Robotics, which limits the maximal movement speed to 125 millimeters per second (directly at the robot controller)
- The “Virtual Fence” option from DENSO Robotics, which recognizes an upcoming collision between the LMK and the robot

That way, operating errors will only cause an error message, avoiding injuries and damage to your equipment or DUTs. The user cannot edit these options with the LMK Position software to further ensure safety.

To further optimize the safety of the equipment, TechnoTeam has integrated an additional “Virtual Box Monitoring”, which further restricts the maximal movements in automatic mode. It enables collision detection based on a bounding box derived directly by TechnoTeam. The customer can edit it to account for the position of the measurement object or other mechanical objects within the Virtual Fence (Figure 2, right).

Of course, TechnoTeam or our partner will provide a declaration of confirmation and the underlying risk analysis according to the applied safety standards.

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*Level 1: Mandatory: emergency button and safety sensors at the robot controller*

*Level 2: Mandatory: certified Denso safety options to limit speed and movement range*

*Level 3: Optionally: editable movement limitation via LMK Position*

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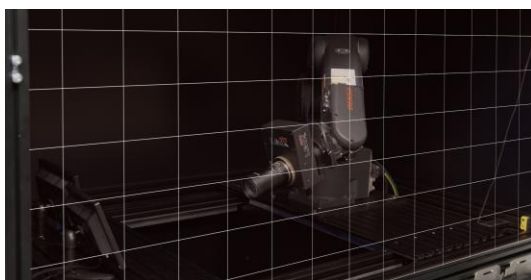


Figure 2: Left: Safety Level 2: Fixed position monitoring of robot and camera relative setup;

Right: Safety Level 3: User-adjustable position monitoring to account for moveable objects within the fixed position monitoring

## Integration Requirements

The preferred way to integrate LMK Position is to place it on our specifically designed ALU Profile Rack. Its height and layout are designed such that the robot can ideally perform horizontal and vertical measurements. The rack can hold the robot, its controller, and optionally a 19" operating computer. Further, the rack ensures a safe and vibration-free operation of the robot.

The rack should be fixed to the ground or a wall to ensure that the relative position to mechanical barriers such as walls does not change. That way, the Robot Position Monitoring will work ideally. The overall weight of the complete system is less than 150 kg. TechnoTeam offers two integration options:

### LMK Position with mechanical barrier

The first is a room integration, where the complete system is placed inside a measuring (or fenced) room. For each door of the room/fence, a certified safety sensor ensures safety. This is the recommended option as it offers the most flexibility regarding lenses that can be used while being cost-effective and compact as simple sensors can be used. The only drawback is the space requirement.

Due to our three-level safety approach, the fence only needs to hinder a human from entering the safety area.



*Figure 3: Scheme of a room Integration: Due to longer measurement distances longer focal length lens systems can be used*

### LMK Position free-standing lab Integration

If there no complete room or fence is available, it is also possible to install the system (robot, rack, and LMK) without a physical barrier inside a lab. In that case, a light curtain is used to ensure safety. Due to safety requirements according to EN 13855, a distance of 1.3 to 1.7 meters to the maximal movement range of the robot needs to be ensured.

### Multiple measurement stations

In a suitable room alignment, multiple measurement locations including, large distance (BlackMURA). Short distance (conoscope) as well as vertical and horizontal can be designed in different directions. Fixed parts can be included in the Safety concept at the Denso level. Also, a moveable desk can be used in combination with the changeable safety function.

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***Depending on the space, multiple measurement positions can be designed in different directions: Large distance (BlackMURA), short distance (conoscope), horizontal, vertical, climate chamber, etc.***

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Table 1 provides an overview of possible integration options for LMK Position.

	<b>Mechanical barrier</b>	<b>Free-standing lab Integration</b>	<b>Cabinet</b>
<b>Costs</b>	Low	Medium	High
<b>Safety-Sensors</b>	Door switches	Advanced safety sensors (e.g., light curtain)	Door switches
<b>Space Requirements</b>	Individual: Recommended area: at least 4 m × 2 m	Movement range of robot + 1.3 – 1.7 m in each direction (depending on light curtain)	Individual, but approx. 2 m <sup>2</sup>
<b>Advantages</b>	Extremely flexible and low cost. Darkening of room	Extremely flexible	Very compact working place. Dark Room is realized via cabinet

*Table 1: Overview of integration option with advantages and disadvantages*

**Comment on cabinet integration:** TechnoTeam does not recommend placing an LMK Position inside a (small) cabinet. The movement range and flexibility decrease, and long-distance measurements are usually not possible. In addition, cabinets are more expensive than our rack solution because measures must be taken to avoid vibration coupling.

### Electrical power consumption

The complete system is provided with a grounding plug. We recommend connecting the entire system to a circuit protector/breaker. Connecting the recommended circuit protector is done by the end customer. An example of a suitable circuit breaker is CP33V/15 (Fuji Electric FA Components & Systems Co., Ltd.)

### Additional linear axis (7<sup>th</sup> axis)

To expand the movement range, TechnoTeam offers the possibility to mount the robot on a 7<sup>th</sup> moving axis. Such a setup ensures that e.g., driver and co-driver vantage points can be reached without changing the position of the DUT. The basic safety considerations are not affected by the 7<sup>th</sup> linear axes.