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ROBOT CALIBRATION WITH TCP-MEASURING INSTRUMENTS FROM CAPTRON

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Application Note

ROBOT CALIBRATION
WITH TOOL-CENTER-POINT MEASURING

What is a Tool Center Point (TCP) and what is it used for?

State-of-the-art robotic automation systems rely on high accuracy. Whenever harsh environments, wear, or tool changes are part of the application, repeated tool checks or recalibrations are required to maintain high accuracy and quality over time.

To describe a tool in robotics a coordinate reference system, called Tool Center Point (TCP) is used.

The TCP and is defined relative to the robot‘s flange (see figure 1). The tool coordinates can be entered either directly numerically or measured with a calibration method. When programming an application, the tool coordinate system should be used. If the tool changes, the TCP is now simply adjusted to apply this change to all of the robot‘s motion programs where this tool is used.

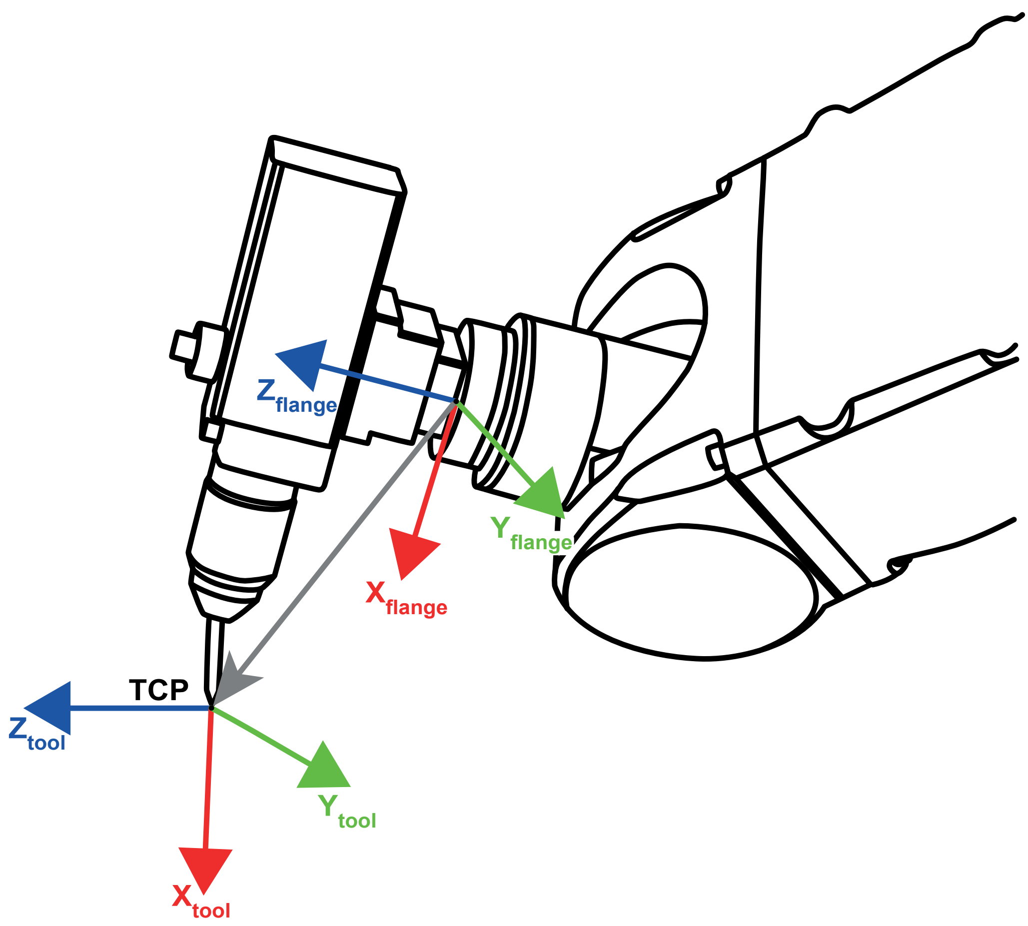

Figure 1: Tool coordinate system (TCP) relative to the robot’s flange coordinate system

In many applications, such as dispensing or welding, the change of tools is permanently ongoing due to wear or bending in harsh environments. Since these applications often rely on the highest possible accuracy, it is necessary to check and calibrate the TCP of the tool on a regular basis, e. g. after each maintenance, at the beginning of a work shift, or even after each process cycle. Recalibration should be an automatic process to avoid human error reducing time and cost, and increasing quality.

How to use a TCP?

CAPTRON offers high precision TCP measuring instruments that enable the customer to perform this automatic recalibration. The instruments work with two perpendicular aligned laser light barriers to determine the robot's tool deviations. The switching signals from the TCP measuring instrument can be used to automatically correct the TCP and thus for automatic movement correction of the robot.

Since the tool has a diameter greater than zero, the laser beam is interrupted for the travel of the tool diameter through the laser beam. The "center" of the light interruption resulting from the falling and rising edge of the light signal of the TCP measuring instrument is the desired tool reference point xref and yref.

It is recommended to move the robot arm on a circular (or square) horizontal path within the TCP measuring device and to interrupt both laser beams twice each, thus storing a total of each two reference positions in x- and y-direction (see figure 2). In this way, the calibration accuracy can be increased by means of averaging. It is also possible to determine the center point of the TCP measuring device where both laser beams cross. At this center point, it can be checked whether the re-calibration was correct since both laser beams are interrupted at the same time.

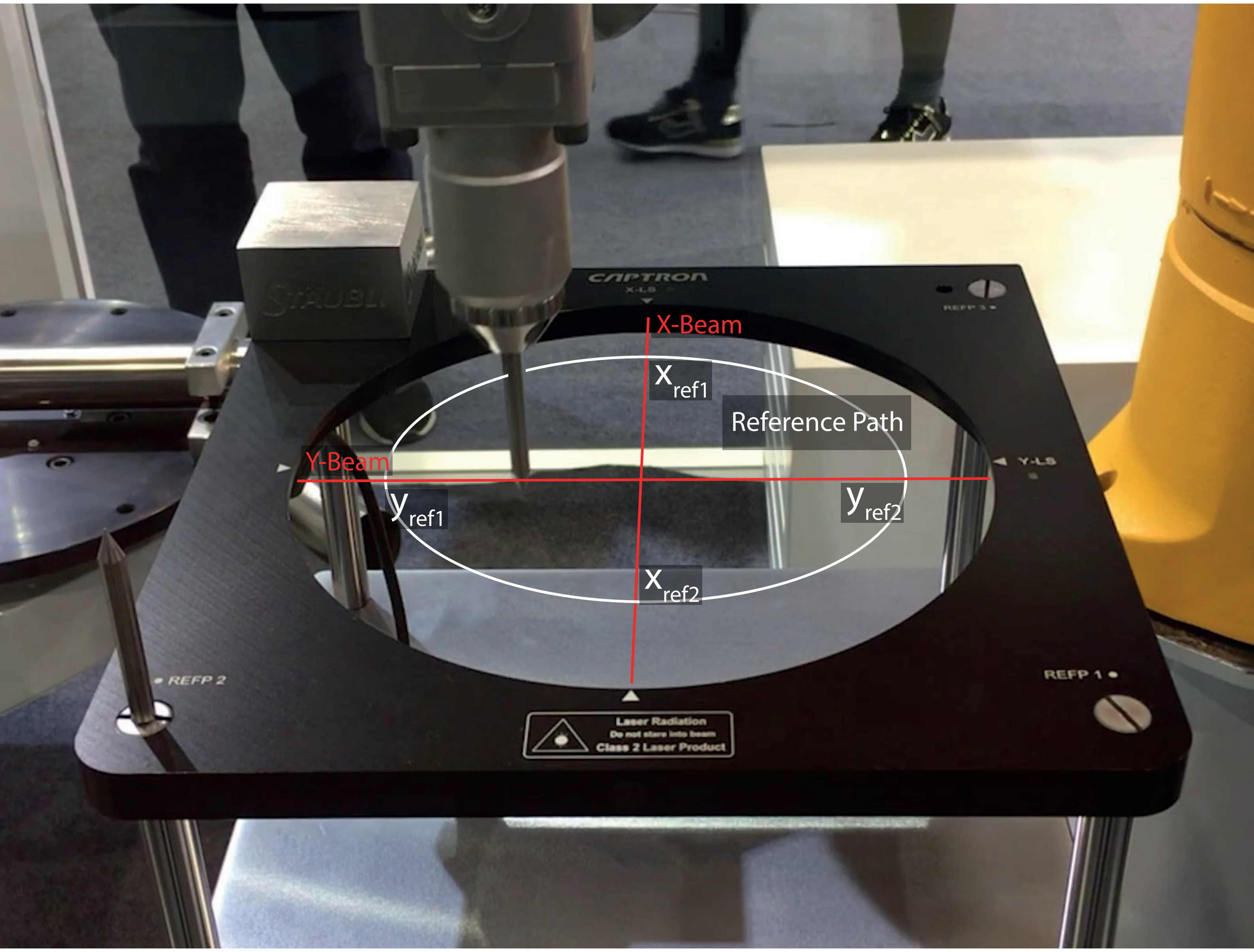

Figure 2: TCP reference measurement

Subsequently, the motion sequences of the robot application are programmed, and the work of the robot is carried out. For recalibration, the tool is moved again on the circular path through the laser beams of the TCP measuring instrument. The deviation from the reference positions is detected and the tool is corrected accordingly in x- and y-direction.

To correct a tilted tool, e.g., a bent welding tip, the robot calibration runs are performed by two circular movements at different heights z_1 and z_2, see figure 3. Each interruption of the x- and y- laser beams results in a correction position $xcal_1$ and $xcal_2$ and $ycal_1$ and $ycal_2$. The tilt angle α can now be calculated and corrected through the TCP deviations between the two recalibration paths.

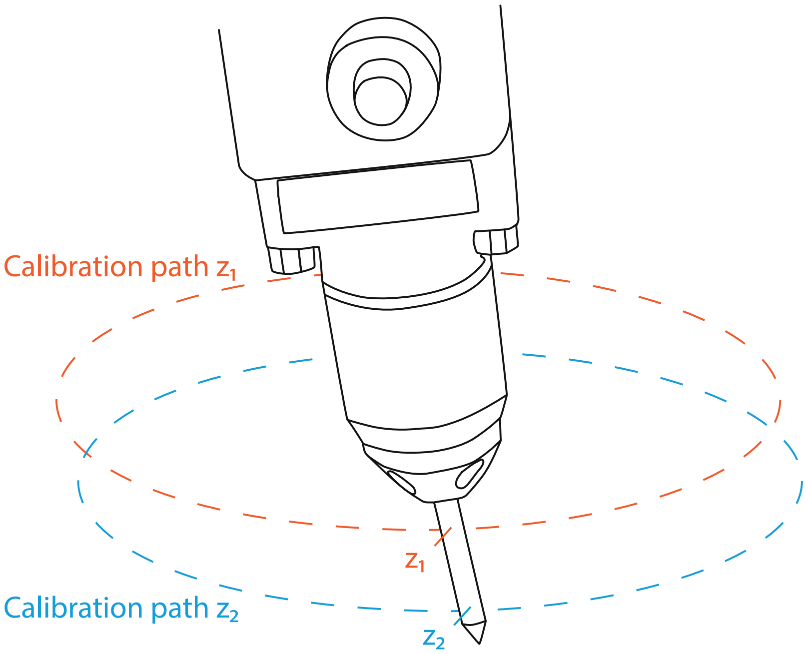

Figure 3: Tilt correction calibration path

Please note that the faster the inputs to the robot system, the higher the accuracy of the procedure. CAPTRON TCP measuring instruments have a high switching frequency of up to 10 kHz. It is recommended to use fast inputs on the robot system as well. Regular inputs lead to large measurement errors at high robot motion speeds.

If you have any questions about our products and the integration into your processes, please contact us at pdm@captron.com.

ABOUT CAPTRON

High-quality, innovative sensor technology products are a synonym for CAPTRON since 1983. We are a German company with further locations in China, North America and Poland as well as sales partners in over 20 countries worldwide. With a focus on expanding digital competencies and linking software with hardware, we are developing and producing an extensive range of capacitive and optical sensors as well as complete sensor systems. Our strategic development is based on three main pillars: digitization, globalization, and customer centricity. Being close to the user and open to customer requirements for innovative and sustainable products and solutions defines our mission statement.

CAPTRON offers products and services for use primarily in the Mobility & Infrastructure as well as Manufacturing & Logistics industries.

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