

# Enabling analysis of Axis cameras failing optical tests in production

*A hundred percent yield in the production of any product is a desirable but often unrealistic goal. Imperfect assembly lines, operator errors or faulty components are a reality, and so also in the production of Axis network cameras. The important thing is to be able to pinpoint what went wrong to attempt to rectify or at the very least monitor it. This thesis has developed an inhouse tool for Axis to analyze how the focus has shifted in cameras that failed optical tests in production – as well as analyze the cameras at an earlier stage, during development, to find out more about their optical characteristics.*

The covid-19 pandemic has made *component shortage* a phrase heard across news channels and a reality for many companies. Axis Communications produces network cameras mainly used for surveillance and has not been spared. The difficulty in keeping a large stock of spare parts has made it more important to not waste the parts that are available. However, production invariably has some drop-out with yields rarely at one hundred percent. The failed units can be caused by many different things such as errors in the handling of components, faulty components, inherent systematic errors in the production line et cetera. Analyzing why units fail in production is key to continuous improvement of production lines and machines.

One of the first steps in the production of Axis network cameras is the alignment of the image sensor and lens. The goal is to position these relative to each other such that a sharp image is achieved. This might sound trivial because many of the cameras have autofocus, but the orientation of the sensor relative the lens must be considered. A misalignment of as little as  $0.02^\circ$  can be enough to cause different parts of the image to be in focus at very different distances. Additionally, shifting focus is undesirable in the application of some Axis cameras. As such the alignment step becomes the only time the focus is set and thus very crucial.

This thesis has developed an inhouse measurement system for Axis network cameras that can assist in understanding why cameras fail optical focus tests in production. It enables analysis of the focus of partially assembled cameras as well as more comprehensive mapping of focus characteristics of units during development of a camera. The focus is quantified and can be measured at objects anywhere from a few decimeters away all the way to infinity (stars in the night sky) using an optical instrument called a *variable focus collimator*.

The measurement system can also analyze the focus characteristics of the camera prior to alignment when the image sensor and lens can move freely relative to each other. This can be used during the development of new cameras to analyze how much a small translation of the sensor relative to the lens shifts the focus. Measurements performed on a fish-eye camera showed that translating the sensor 5 micrometers away from the lens results in the focus shifting from infinity to 300 mm. This information can be used to determine which offset should be aimed for in the alignment process to set the focus at a certain distance.

The work focused mainly on developing the software for the machine. Programs were written that autonomously scans through several sensor positions, object distances, incidence angles and measures the focus at each position. The result is presented both graphically as well as in raw data files that can be used for further analysis. The system is used regularly inhouse by engineers and with further development has the potential of being used at factories during production.