# Welding

*APPLICATION NOTE*

## Introduction

Welding has been an essential tool in the manufacturing industry ever since the advent of the industrial revolution. It is the commonly accepted methods to fuse two metallic objects into one, and has enabled the efficient construction of skyscrapers and steel bridges as well as building of ships, planes, and cars. But modern welding offers much more possibilities than this. Laser welding enables joining objects of various types of materials with very high precision at high speed. The heat load can be minimized and directed precisely where it is needed. Today welding is used in such diverse areas as automotive and aerospace manufacturing, jewelry, microelectronics, medical devices and dentistry, and many more.

## Problem

For optimal control and for best result, particularly when welding small objects such as in jewelry or dentistry, it is desirable to observe the welding spot and surrounding area both during the process and when it is turned off. But welding generates intense light and regardless if it is observed directly by the human eye, through microscope, or with the help of a camera there is a need to attenuate the light. A simple solution is to use a mechanical shutter that is either fully closed (blocking all light) or fully open (letting all light through). If the mechanical shutter is made of a fixed filter with high optical density then the welding can be observed even during operation. Another approach is to use a filter with variable attenuation so that just enough light can be transmitted to see the weld zone both when the process is on and off. This can for example be achieved with two crossed polarizers that can be rotated with respect to each other to vary the transmittance. All these solutions rely on the mechanical motion of parts in one way or another, limiting the speed and accuracy of operation, as well as the durability and reliability of the shutter.

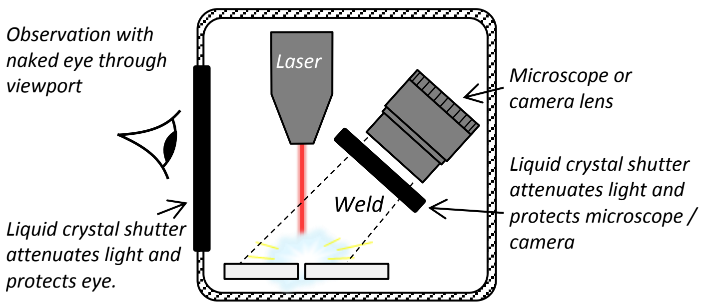
## Solution

One way to realize variable attenuation but without the disadvantages of a mechanical shutter is to utilize liquid crystal (LC) technology, such as in the Fast Optical Shutters offered by LC-Tec. These devices are based on LC cells sandwiched between crossed polarizers. As a voltage is applied to the LC cell the birefringence is tuned, the polarization state is modulated and as a consequence the transmittance through the shutter is controlled. This gives an electronically controlled attenuation that allows for observation of the weld zone during operation as well as when the welding is turned off. As the shutter can be operated on the gray levels the transmittance can be tuned to the desired level for each welding condition. The shutter contains no moving parts making it very fast (closing time ≤ 150us), rugged and reliable (billions of switches), and can have very high attenuation (>14 shade numbers depending on model). It can stay in the optical path at all times so does not require extra space to accommodate for the shutter in the open state as with mechanical slide shutters.

LC-Tec provides different models depending on the requirements, see main characteristics in table below. **FOS-AR** offers fast shutter speed and an electronically controlled transmittance between ≥38.5% and ≤0.022% (corresponding to shade number >9). The **X-FOS(G2)-CE-AR** model offers even higher attenuation with transmittance variable between ≥29% and ≤0.00025% transmittance (shade number >14), as well as extra high switching speed. Shade number 14 is sufficient attenuation for even the most intense light from welding. Both models allow for excellent image quality.

Both pulsed and continuous wave (CW) lasers are used for welding. Depending on the type of laser as well as the shutter model different modes of operation is possible. With a CW laser the attenuation of the shutter is held at the desired level as long as the laser is on and then fully opened to allow for inspection in the absence of the energy source. For pulsed operation, the shutter can be synchronized with the laser pulse so that the light is attenuated only when the pulse is on to maximize the average transmittance.

## Position of the shutter




## Advantages

- ✓ No moving parts
- ✓ Large design freedom
- ✓ Fast switching
- ✓ High contrast
- ✓ Continuous gray scale operation
- ✓ Excellent optical quality
- ✓ Ruggedized
- ✓ Reliable

## Main characteristics

| | *FOS-AR* | *X-FOS(G2)-CE-AR* |
|---|---|---|
| **Open state transmittance** | ≥38.5% | ≥29.0% |
| **Closed stat transmittance** | ≤0.022% (>9 SN)* | ≤0.00025% (>14 SN)* |
| **Closing time ($T_{100}$-$T_{10}$)** | ≤150us | ≤50µs |
| **Opening time ($T_0$-$T_{90}$)** | <35ms | ≤1.6ms |
| **Size** | Custom designing up to 14 x 16 inches | |

**: SN = Shade Number, defined as 7/3(-log(T))+1*

***For more information, please contact us at: info@lc-tec.se.***