

Introduction

The Beck Optronic Solutions (Beck) range of zoom lenses are sometimes compared to apparently equivalent “Commercial Off The Shelf” (COTS) products available from the large commercial lens manufacturers. We have prepared this paper to enable our Customers to make a more objective, realistic, and accurate appraisal and comparison regarding our range of zoom lenses.

The relative merits of one zoom lens versus another in respect to optical performance can be objectively assessed by consideration of light gathering capability, modulation transfer function (MTF) performance and boresight performance. These measures provide real insight into system performance.

The results clearly show that there are significant and meaningful benefits in using Beck lenses regarding optical performance as well as other relevant features and performance.

Measured Optical Performance

First consider optical performance. For this purpose, we examined two COTS visible waveband zoom lenses supplied by two different zoom lens manufacturers. They were in use by a customer who was considering upgrading to a Beck zoom lens. The two COTS lenses were quoted as:

Lens 1: 10-320 mm, f/2.5

Lens 2: 14.25-384 mm, f/5.25

The lenses were analysed in our test laboratory for focal length, F-number, boresight stability, and MTF (using Matrix MTF Software from Image Science).

Focal Lengths

Lens 1: Quoted 10 mm to 320 mm – Measured at 10.34 mm to 321.33 mm.

Lens 2: Quoted 14.25 mm to 384 mm – Measured at 14.09 mm to 382.23 mm.

F-number

Lens 1: Quoted f/2.5 – Observed at f/2.95 at 10.34 mm focal length and f/24 at 321.33 mm focal length.

Lens 2: Quoted f/5.25 – Observed at f/7.05 at 14.09 mm focal length and f/40 at 382.23 mm focal length.

For comparison purposes the Beck 10 mm to 220 mm visible waveband zoom is f/4 at 10 mm focal length and f/4 at 220 mm focal length. This gives the Beck lens 36 times the light gathering performance of Lens 1 and 100 times that of lens 2 at the longest focal lengths. Similar performance is true for all Beck zoom lenses. The quoted F-number of a Beck zoom lens will always be clearly defined from wide to narrow field of view.

Boresight

Lens 1: No quoted performance – Measured boresight errors of 55 μm in the vertical and 300 μm in the horizontal.

Lens 2: No quoted performance – Measured boresight errors of 100 μm in the vertical and 79 μm in the horizontal.

Again, for comparison purposes, the Beck 10 mm to 220 mm visible waveband zoom lens has typically 10 μm boresight error in either axis.

Boresight is very important in applications where the user is attempting to zoom in quickly to a specific object, and especially in targeting applications.

MTF

Modulation Transfer Function or MTF provides probably the most objective measure of the quality of optical performance for the whole lens system.

Lens 1: Measured average MTF of ~14% at 100 cycles/mm at 10.344 focal length. There was significant coma, suggesting poor build controls and test standards.

Measured average MTF of ~14% at 100 cycles/mm at 321.33 focal length and f/24.

Lens 2: Measured average MTF of ~30% at 100 cycles/mm at 14.09 mm focal length.

Measured average MTF of ~3% at 100 cycles/mm at 382.33 mm focal length and 28% at 20 cycles/mm and f/40. There was also significant spherical aberration.

For comparison purposes, the Beck 10 mm to 220 mm visible waveband zoom has an average MTF of 45% at 100 cycles/mm at 10 mm focal length and f/4 and 15% at 200 mm focal length and still at f/4.

The benefit of good MTF performance is the resolution of fine detail with improved recognition range.

Often COTS zoom Lenses are fitted with extenders, which may give the required focal length range but are not matched to the optical design of the zoom lens giving colour correction problems which adversely affect the MTF performance.

Where extenders are necessary Beck lenses use an integrated optical design to optimise MTF performance.

Testing and Quality Control

COTS lenses by their nature are produced in large volumes, and the quality controls applied are tailored accordingly. As seen above, the variances to quoted performance are considerable and meaningful, and the performance will be highly inconsistent between lenses even in the same production batch simply because the level of testing will be limited.

In contrast, all BECK lenses are individually MTF tested and calibrated, and individual test results can be provided for each lens. This ensures that performance is maintained at the quoted specification and variation between individual lenses is within specified tolerance.

Mechanical Design and Control Electronics

COTS zoom lens design is quite different to that of a Beck design. Whereas a COTS zoom relies upon mechanical cams to provide the zoom function, Beck zooms employ a rail design. The lens groups are in separate cells along the rail and can be independently moved. During the set-up process, each system is individually programmed and trimmed to ensure optimum optical performance throughout the zoom from wide to narrow field of view. The individual optical elements do not rotate, and boresight is maintained throughout the zoom travel.

Beck zoom lenses are fully motorised by design, and include a sophisticated control electronics package, enabling full remote control of functions including zoom, focus, filter selection and aperture. The complete system is designed for demanding physical environments and to meet defined military standards for robustness (shock, vibration, etc.) and environmental exposure.

COTS lenses are often purchased as a standard lens, and then modified to motorise the zoom, focus and iris. These modifications nearly always result in a compromise design addition which must be attached to the lens and which applies loads to bearings not designed for that purpose.

Even if the motors are integrated effectively, they still must be driven in a controlled way between defined end positions, and this control is provided by Beck through USB or RS422 interfaces from a pre-determined set of commands. Beck electronics provide PID control for each of 6 motors and conform to EMC standards for emissions and susceptibility, occupying the minimum space by using surface mounted components.

The same electronics can be used to drive any Beck zoom lens from 20mm focal length to 2000mm focal length because they can be programmed to match any zoom characteristics.

Matching to Sensor Characteristics

Beck lenses are typically optimised to the specific performance required by the selected sensor and the specific Customer application. The coatings can be specifically optimised to meet performance requirements.

Features

COTS lenses will typically be designed for a standard interface to the camera, very often C-mount. BOS can normally accommodate any standard interface, or work with a custom interface.

Standard interfaces such as C-mount provide no ability to centre the sensor so that the central pixel is indeed in the centre of the image plane. The BOS design incorporates an adjustment mechanism to enable precise centring of the sensor.

COTS lenses offer no automated ability to change the filters in the system. The BOS zoom lenses have an optional filter 'wheel' to enable the user to change the filter under motorised control.

Customised Design

Of course, by definition, COTS lenses are available as standard products only.

We own and control all aspects of the design of BOS zoom lenses. Therefore, we can customise any lens to meet the precise requirements of our Customers where they are of key importance. That may mean a small modification to an existing design – or a completely new system design.

Clearly, there are cost and timeline benefits to adopting an existing design - but the option to customise or start afresh is always available if required.

Summary

There is a very considerable benefit to be gained by selecting a BOS zoom lens versus a COTS lens from the major commercial brands:

- Optical performance is significantly better;
- Each lens is individually optimised and tested;
- The design is qualified for demanding defence and security applications (i.e., relevant MIL-SPEC);
- Non-standard variants / features can be accommodated.

There is of course a modest premium, but when the full costs of customisation of COTS lenses to make them fit for purpose is properly accounted for, the difference is often quite marginal.

There may be situations where the application is undemanding, and a simple COTS lens will suffice.

But where the application requires the best available optical performance, qualified ruggedness, or sophisticated remote control and features, the BOS zoom lens offers outstanding performance and remarkable value for money.

Beck Zoom Lens Range

The following standard zoom variants are available from BOS currently. Full data sheets can be found at www.beckoptronic.com/products/zoom-lenses

The following variants cover the visible / NIR wavebands (400nm to 1050nm):

- 150mm to 600mm, f/5.6
- 210mm to 840mm, f/7.8
- 300 mm to 1200 mm, f/11.2
- 150mm to 1200mm with switchable range extenders, f/11.2
- 500mm to 2000mm, f/18.7



Available in a more compact form factor for visible or visible / NIR wavebands:

- 10 mm to 220 mm, f/4



Also available in the same compact form factor for the SWIR waveband (0.7 μm to 1.7 μm)

- 20 mm to 200 mm, f/4
- 26.5 mm to 265 mm, f/5.3
- 33 mm to 330 mm, f/6.7
- 53 mm to 530 mm, f/10.6

About Beck Optronics Solutions

Beck has a reputation for excellence in design and manufacture of precision optics that can be traced back over 175 years. near London, UK, Beck delivers complex, integrated electro-optic systems for defence and commercial use across the electromagnetic spectrum from UV to LWIR. **For pricing or further information please contact us at:**

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Why select a Beck zoom lens over a COTS lens

