

Demystify Fiber Inspection Probe Technical Specifications

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PREFACE

The intent of this application note is to promote a better understanding of video inspection probe specifications and features. Properly understanding the key specifications and features will greatly facilitate the decision process involved in acquiring such devices. Understanding the key aspects of fiber inspection probes will also help users understand how fiber inspection probes operate, thus enabling them to maximize the full potential of these devices.

FIELD OF VIEW (FOV)

This specification refers to the area of the ferrule that is visible to the inspection probe. The FOV is represented in horizontal and vertical lengths. If no image cropping is performed by the device software, a larger FOV will result in a smaller fiber size on the display. A large field of view will be very useful when inspecting multifiber connectors; for example, a 912 μm FOV enables up to four fibers to be viewed at the same time for a single-row MT ferrule, or up to eight fibers for a dual-row multi-fiber push-on (MPO), which greatly facilitates inspection.

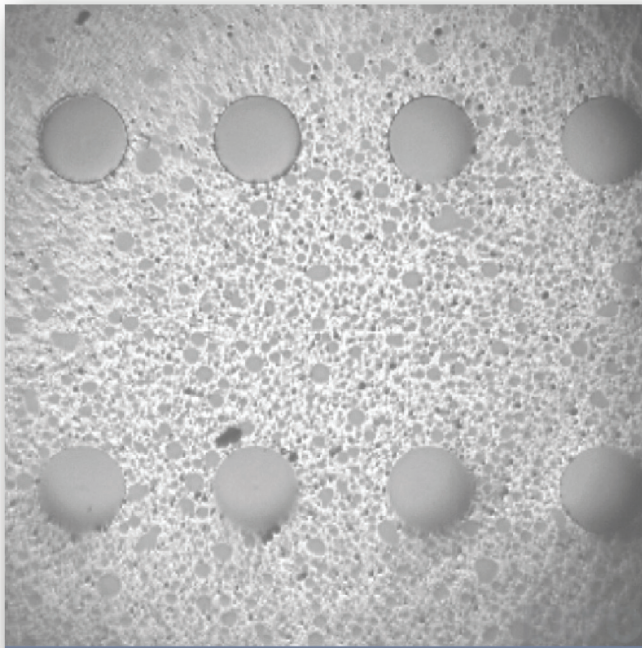


Figure 1. Image of a multi-row MPO-type connector taken with a fiber inspection probe featuring a 912 μm x 912 μm FOV

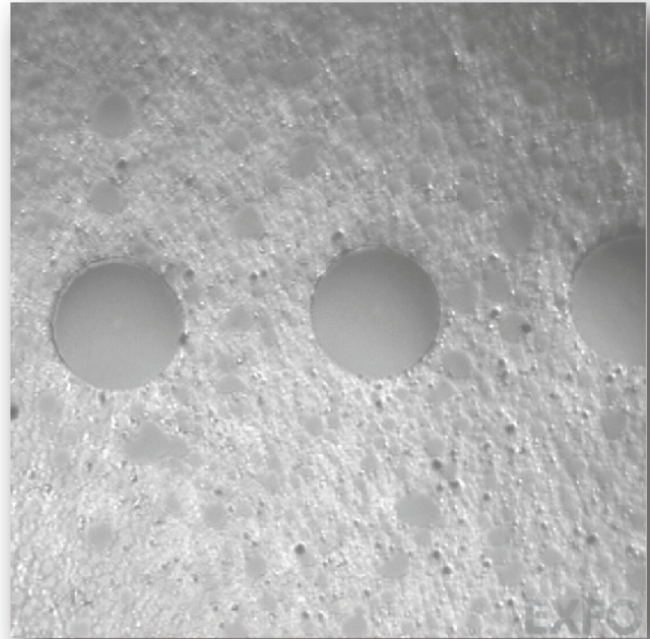


Figure 2. Image of a multi-row MPO-type connector taken with a fiber inspection probe featuring a 608 μm x 608 μm FOV (only one row is visible)

Having a large field of view also makes it possible to crop a portion of the image, thus optimizing the image quality rendered on-screen. Cropping also means that the image can be centered, thereby allowing its dimension to be optimized on-screen for optimal magnification. This automation function is referred to as "auto-centering." Manufacturers typically use a rectangular field of view due to the commercial availability of complementary metal-oxide semiconductor (CMOS) or charge-coupled device (CCD) camera types, which use a 4:3 ratio. Because optical fibers are round, a square FOV is more effective, as it allows for optimal magnification levels without wasted screen space.

MAGNIFICATION

Magnification is specified as the relation between the physical fiber size and the displayed fiber size on-screen. A number of manufacturers use numeric values to define high and low magnification levels. Typical values are 200x and 400x. However, using numeric values often results in misinterpretation of the inspection test set, which should always refer to a specific screen size. Failure to specify a screen size will render this value useless. For example, some vendors are advertising 400x magnification capability on 3.5-inch or 5-inch screens, when in fact the magnification is actually around 200x when properly measured. If the magnification is specified as a 400x-capable device, the image of the 125 μm cladding on-screen should have a diameter of 5 cm to meet the 400x specification.

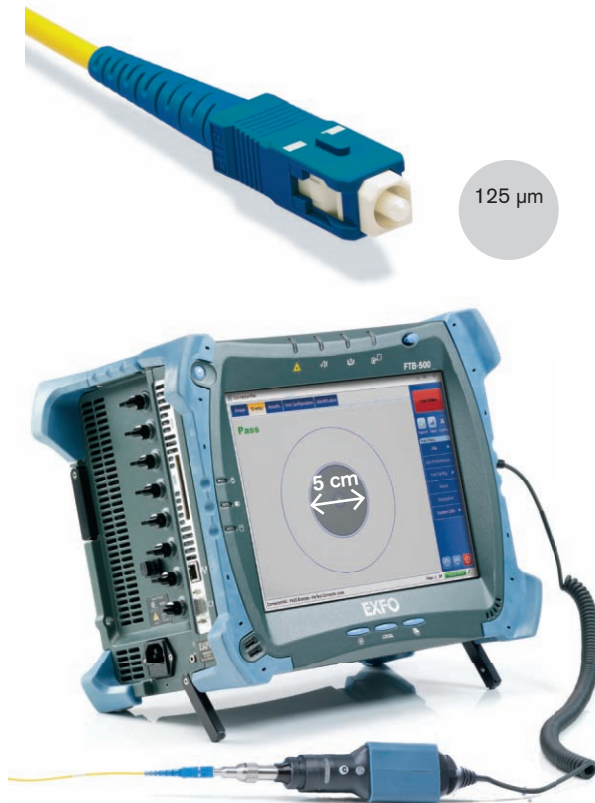


Figure 3. Example of the fiber size needed to achieve 400x magnification on-screen

It is critical to understand that the display magnification is not a critical parameter for PASS/FAIL analysis with respect to the criteria stated in fiber connector quality standards such as IEC-61300-3-35. Refer to the Device Resolution section for a better understanding of this specification.

ILLUMINATION

Fiber inspection probes use various wavelengths (color) to illuminate fiber. Most probes use a high-brightness blue LED. The choice of a blue LED is based on its shorter wavelength, which is optimal for small-defect detection. Other colors are also used, such as red LEDs. However, the red LED does not provide the same level of optical resolution due to its longer wavelength. Red LEDs can be used by entry-level probes that deliver less resolution, while high-resolution probes typically use blue LEDs. Another issue with the LED illumination is its linewidth, which should be very small. The wider the LED's spectrum, the more difficult it becomes to obtain a clear image. This is due to lens material dispersion, which changes the focal length of the system. The optimum lens position for one particular wavelength will be different for another, leading to a blurring effect if the spectrum is too wide. A good example of this would be using a white LED, which has a very wide spectrum and typically produces relatively hard-to-focus images. In some cases, the user may not be able to optimize the focus, which will lead to blurred images affecting the performances of the inspection apparatus. Blurred or slightly blurred images may ultimately provide false positives when paired with pass/fail analysis software, because some defects may be easily missed.

THE VISIBLE SPECTRUM • Wavelength in Nanometers

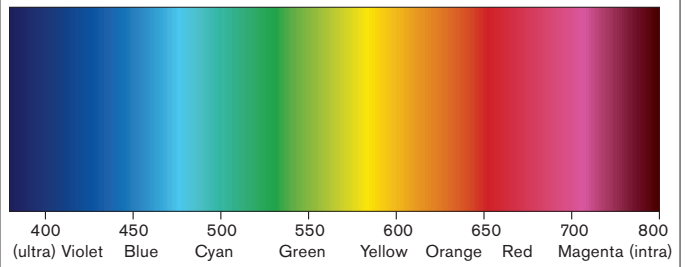


Figure 4. The visible wavelength spectrum

FOCUS

The focus mechanism is also very important, and has a direct impact on the quality of the image and the time required by the user to adjust the image. The ratio between the number of turns and the displacement of the lens assembly within the adjustment mechanism can greatly differ from one model to another. Most fiber inspection probes adjust the image's focus by displacing the lens using either a cam system or a linear screw motion. Depending on the mechanical configuration, the resolution of this movement may be insufficient for easy focus adjustment. For example, some models will require two complete turns for a given movement, whereas another may only require a single turn. In such cases, the user may experience difficulties when trying to fine-tune the adjustment, because even a small movement of the focusing knob will have a great impact on the focus adjustment. High-resolution probe models feature an adjustment mechanism with multiple revolutions of the adjustment knob per focus length to facilitate fine-tuning of the image's focus.



Figure 5. Example of a multirevolution focus mechanism

CAPTURING DEVICE TYPE

Video inspection probes feature a capturing device, which is most often a CMOS or CCD type. Each type and model features different characteristics with different effects on performances and image quality. For instance, some capturing devices can produce more electronic noise on the electrical signal than others, which can have a profound effect on the repeatability of the signal acquisition. This in turn affects the result when analysis software is used to assess the image quality, because small defects with faint grey shades may trigger analysis on one occasion, but be missed the next. Averaging, exposure time, and other sophisticated analysis algorithms may also be used to enhance the image quality.

DEVICE RESOLUTION

The device resolution, including the optical magnification of the image, should be specified in micrometers/pixels. The device resolution is equal to the pixel distance of the CMOS or CCD divided by the optical magnification.

For example, a CMOS with 5.5 microns of pixel distance and 10x optical magnification will have a device resolution of 0.55 micrometers/pixels, whereas another device with 1.4 microns of pixel distance and 2x optical magnification will have a device resolution of 0.70 micrometers/pixels. The former will result in better device resolution, even if the CCD or CMOS used is better. Specifying the CMOS or CCD resolution in pixel distance alone is therefore insufficient. The smaller the size per pixel, the better the inspection probe's resolution, and the easier it is to detect small defects.

An alternate and even simpler description of the device resolution would be the number of pixels in a cladding diameter. Having 250 pixels in the cladding diameter is clearly better than only having 200 pixels.

NUMBER OF FRAMES PER SECOND

The number of frames per second (fps) determines how many images are transferred between the inspection probe and the display. If the rate is too low, the user will be subjected to a delay making focus adjustment very difficult and time-consuming. Typically, a rate of 10 fps or higher is preferred, because at this rate users will not be subjected to delays, and this in turn allows for easier focus adjustment.



Figure 6. Fiber inspection: All connections must be clean and free of contaminants

CONCLUSION

Today's fiber networks are under greater stress than ever before due to demanding transmission systems carrying large amounts of data. Ensuring the reliability of these networks is crucial. Unfortunately, networks are only as strong and reliable as their weakest links, which are usually the connect points in an optical system. Ensuring that every connection is pristine will greatly improve the likelihood that the network will be able to perform to the best of its capacity, and this process begins with fiber inspection.