Application Note: Configuring the Model ShapeShifter™ for Z-scan Measurements

(Also available as a service)

Z-scan is a single beam technique developed by Prof. Eric van Stryland[1] at CREOL, University of Central Florida. This technique is conceptually simple but not so easy to implement. It has proven to be a very sensitive method for measuring the nonlinear refractive index and nonlinear absorption coefficient in transparent materials. The simplest implementation involves the translation of your sample in the vicinity of the beam waist of a focused Gaussian laser beam and measuring the transmission changes in the far field with a detector.

There are a few variants of Z-scan that permit the measurement of nonlinear absorption coefficient and nonlinear refractive index simultaneously. The simplest involves standard "open aperture" and "closed aperture". The flexibility of the Model ShapeShifter™ for simple single beam Z-scan and more complex two-color[2] and time-resolved[3] measurements will be discussed.

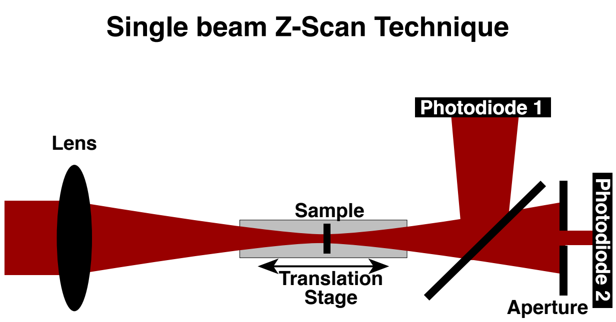

Figure 1. Schematic implementation of single-beam Z-scan technique

Figure 1 illustrates a closed aperture single beam Z-scan measurement using the Model ShapeShifter™, a fully configurable/re-configurable nonlinear and/or pump/probe spectrometer that can be easily adapted to your existing and future research needs[4]. The Model ShapeShifter™ configured with a Model CPA-Series kHz laser, two NOPAs a SHG/THG module (STORC) and Model TrPPS sample/detection system for multimodal imaging is shown in Figure 2.

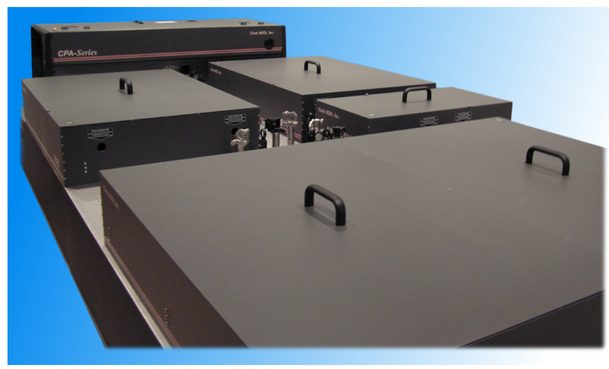

Figure 2. Model ShapeShifter™ from Clark-MXR is a reconfigurable nonlinear and pump-probe spectrometer enabling a variety of measurement techniques including Z-scan.

For the sake of simplicity, we demonstrate the closed aperture, single beam Z-scan technique with a sample of fused silica using the Model ShapeShifter™ pumped by a Model CPA-Series laser. Briefly, the sample was translated through the beam waist of the focused Gaussian laser beam and it's transmittance detected with a photodiode. The intensity of the laser beam passing through the aperture is modulated in the sample due to the optical Kerr effect.

Open Aperture

A change in the transmitted intensity as the sample translates through the waist of the beam measures the multiphoton (nonlinear) absorption. In this case the intensity dips as the sample translate through the focus because the nonlinear absorption is at it's maximum where the peak power is highest.

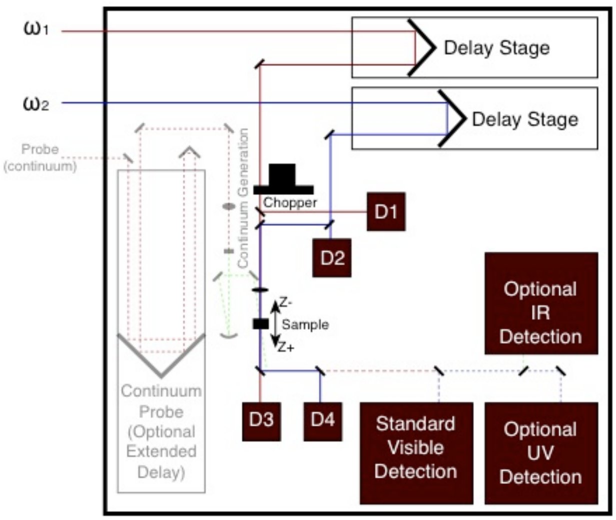

Figure 3. Model ShapeShifter™ configured for Time-resolved, two-color Z-scan. This setup is a reconfigured version of the single beam Z-scan illustrated in Figure 1.

Closed Aperture

A photodiode placed after a partially closed aperture measures the fraction of the beam intensity that passes through the aperture at the center of the beam. A lens (called the Kerr lens) is generated by the high peak intensity at the focus in the material, thereby altering the intensity of the light incident on the photodiode. Consequently the photodiode sees a peak and valley created by the lens in the sample as it moves through the focus. In the absence of nonlinear absorption, this trace is symmetric with no further data processing required.

In the presence of nonlinear absorption in the sample, the signal trace obtained with closed aperture becomes asymmetric. Then both open and closed aperture traces are needed to reconstruct Z-scan data to obtain the nonlinear refractive index.

The data obtained for a fused silica sample with the Model ShapeShifter™ configured for the simplest implementation of Z-scan technique is shown in Figure 4

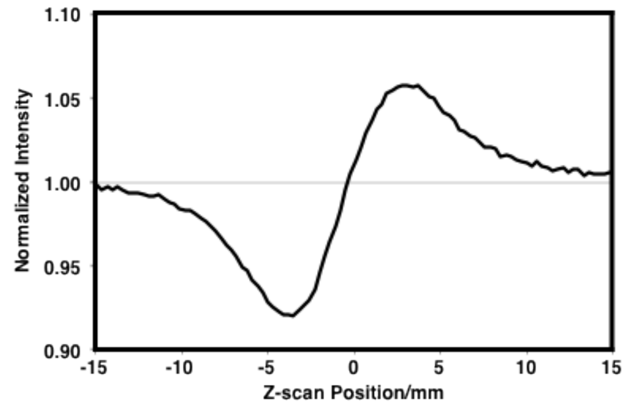

Figure 4. Z-scan data obtained for fused silica with single-beam Z-scan. Data collected with Model ShapeShifter™ configured for single beam Z-scan with Model CPA-Series as the pump source.

Two-color Z-scan can be used to measure the nonlinear refraction and absorption in the presence of strong excitation or non-degenerate nonlinearities. These alternate approaches are facilitated by the modular architecture of the Model Shapeshifter™. And, when combining different frequencies and time delays with other spectroscopic techniques (e.g. transient absorption, CARS, SRS, etc.), the Model Shapeshifter™ becomes the most versatile and flexible photonics research tool on the market today.

Please contact us at sales@cmxr.com if you would like us to make a Z-scan measurement for you - or to learn more about Model Shapeshifter™ and how it can be configured for your microscopy/spectroscopy research needs.

References:

1. M. Sheik-Bahae, A. A. Said, and E. W. Van Stryland, Opt. Lett. 14, 955 (1989).
2. M. Sheik-Bahae, J. Wang, R. DeSalvo, D. J. Hagan, and E. W. Van Stryland, Opt. Lett. 17, 258 (1992).
3. H. Ma, A. S. Gomez, and C. B. de Araujo, Appl. Phys. Lett. 59, 2666 (1991).
4. Note: Additional equipment may be required.

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