APPLICATION NOTE

QUAD LASER POSITION SENSING DETECTORS AND MONITOR

IF YOU NEED TO TRACK, CONTROL OR MEASURE THE POSITION OF YOUR PULSED LASER BEAM, THERE IS ONLY ONE PRODUCT ON THE MARKET THAT CAN DO THAT, OUR NEW QUAD-4TRACK LASER POSITION MONITOR.

INTRODUCTION

Our new QUAD-4Track takes advantage of the superior performance of our Pyroelectric Quadrant Detectors over Silicon quad and lateral effect photodiodes. They are fast, handle high peak powers without saturation and respond to lasers across the spectrum, from ultraviolet to far-IR. Our QUAD-E detectors are designed to measure pulsed lasers and QUAD-P detectors for CW or Quasi-CW lasers. Our detectors come in two sizes: 9 mm square or 20 mm square. The QUAD- 4Track Laser Position Monitor is a powerful, 4-channel, microprocessor based instrument that includes a full speed USB interface and versatile LabView Software. Furthermore, it not only measures beam position, but also the power or energy of your laser.

HOW DO WE MAKE OUR QUADRANT PYROELECTRIC DETECTORS?

We start with a single piece of $LiTaO_3$, about 10 mm square and we deposit metal electrodes on both sides. Then, using a photolithographic process, we define four individual detector elements (active areas) on the top side of the crystal, separated by a 50 µm gap or dead space (see figure 1). The active areas are defined by individual metal electrodes which collect the charge generated as the detector element heats up when exposed to a pulsed, chopped or modulated laser. These four current outputs are connected to our 4-channel, current-to-voltage preamp in the QUAD Detector. The QUAD-E detectors are designed to integrate the output from the quadrant detector when exposed to a pulsed laser, while the QUAD-P detectors are designed to output a square voltage waveform that is directly proportional to the power in an optically chopped CW laser.

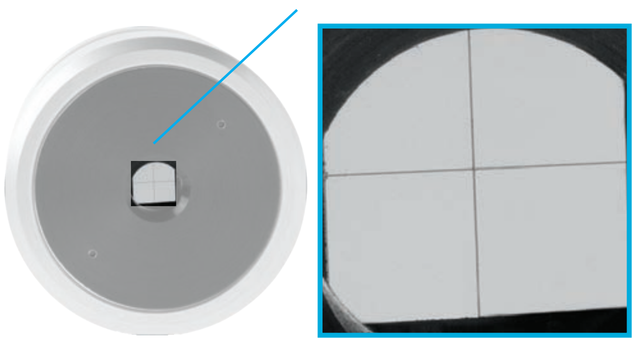
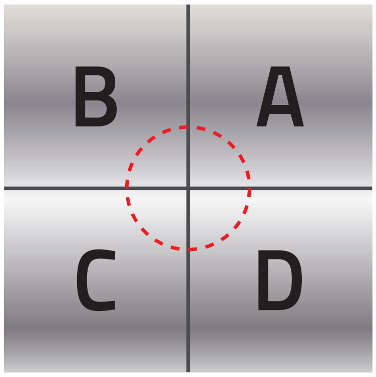


Figure 1: QUAD detector close-up that show the 4 detector elements.

APPLICATION NOTE

HOW ARE QUAD DETECTORS USED TO MEASURE LASER POSITION?



$$V_x = \frac{(A + D) - (B + C)}{(A + B + C + D)}$$

$$V_y = \frac{(A + B) - (C + D)}{(A + B + C + D)}$$

Figure 2: Schematic of the QUAD detector elements and the equation used to determine beam position

The first requirement when employing a quadrant detector for a laser position sensing application is that the laser beam be present on all four QUAD detector elements simultaneously (as shown in Figure 2 below). This is necessary to have sufficient data to determine an X and Y position. The diagram and equations shown in Figure 2 below will help you understand how this works. By assigning the letters A through D to the quadrant elements, the normalized transfer functions for the displacement (X and Y) can be defined. Vx tracks the displacement of the centroid of the laser beam from physical center of the quadrant detector in the X direction. Vy tracks the displacement of the laser beam in the Y direction. The SUM term (A+B+C+D) is used to normalize the X and Y terms. It prevents fluctuations in the energy or power of the laser from affecting the position measurement. As you can see, when the laser beam is in the center of the quadrant detector, the Vx and Vy values go zero. This is known as the "Null" position, a goal when using the quadrant detectors for centering and alignment applications. The beam moves off center, the value of Vx and Vy will no longer be zero, but rather a positive or negative number less than one. Positive if moving in the +X or +Y direction and negative if moving in the –X or –Y direction.

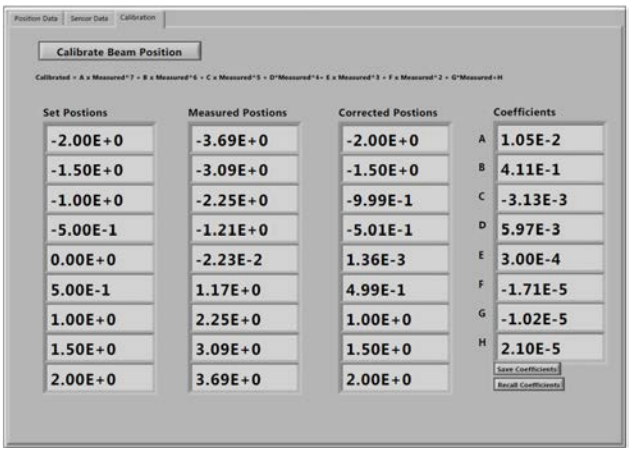


Figure 3: Calibration screen of the QUAD software

IS THERE A NEED TO CALIBRATE THE QUAD DETECTOR FOR ABSOLUTE MEASUREMENTS?

The answer to this question is yes ! The current or voltage outputs of a quadrant detector are inherently non-linear as you move away from the center. The values of Vx and Vy give you the position of the laser in "relative", not absolute, terms, unless you physically calibrate your sensor. To measure the position of the laser beam in absolute terms, i.e. µm, you need to calibrate the QUAD detector for a given set of conditions (i.e. beam size, shape, intensity and total displacement). This can be a challenge when using the QUAD detectors in an analog mode, but, when combined with a powerful, microprocessor based, multi-channel instrument, like QUAD-4Track, it's not difficult at all !

The calibration procedure, for a uniform beam, when using our QUAD-4Track system, requires the QUAD detector to be mounted on a micrometer driven X-axis stage. Our application software asks you to bring the laser beam to the center (i.e. null point) of the QUAD detector. It then requires that you move the detector, using the micrometer drive, to nine predetermined positions (i.e. from -2.00 mm through +2.00 mm). At each point, raw Vx and Vy data is taken. Once the process has been completed, our software fits a 7th order polynomial equation to the data, calculates position correction factors and applies them to the raw data (Figure 3). You're now ready to measure the laser beam position in absolute terms. Position resolution can be as good as a few µm !

APPLICATION NOTE

CAPABILITIES AND FEATURES

Our new QUAD-4Track was designed to support our Pyroelectric Quadrant Detectors QUAD-E (energy) and QUAD-P (power) series. It features 4-channel, multiplexed, digital electronics that measure the pulse energy or CW power on the falling on the QUAD detector elements. It computes the SUM and DIFFERENCE in two axes to provide normalized X and Y position data on a millisecond time frame. It has four decades of range, 20 μJ to 20 mJ or 20 μW to 20 mW.

It includes an external trigger input which is especially handy on the lower ranges to prevent triggering on noise. We've included a multiplexed analog output that provides the individual voltage output of each channel (see Figure 4). This is extremely useful when setting up the system and/or for a quick optical alignment process.

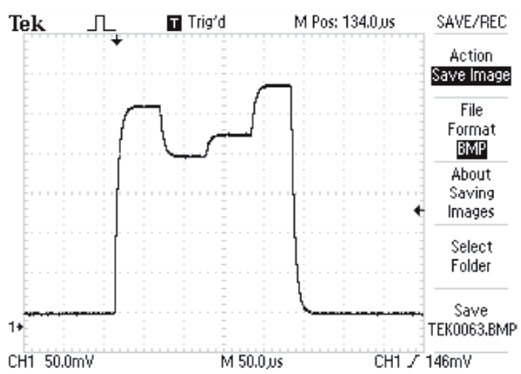


Figure 4: Analog ouput of a QUAD detector as seen on an oscilloscope.

The combination of our Pyroelectric QUAD detectors and QUAD-4Track Laser Position Monitor allows one to measure the displacement or position of Pulsed, CW and/or Quasi-CW lasers from Deep UV to Far-IR. Pulses can be from fs to ms in length, from μJ to mJ, and a single pulse to 1000 pps. CW or Quasi-CW (i.e. high rep rate lasers) in the μW to mW range can be measured. CW sources require the use of an optical chopper running at about 50 Hz (SDC-500 available in option).

MANY APPLICATIONS

Our QUAD-4Track has many applications. Here are a few of them:

- Laser alignment
- Mirror alignment
- Laser beam steering measurement
- Laser tracking and control
- Laser position stability over time and temperature
- THz beam (image) alignment

APPLICATION NOTE

CAPABILITIES AND FEATURES

QUAD-4Track includes powerful, standalone LabView Software which is used to control the instrument and to collect and display data in a graphical X-Y format. In addition, it displays total pulse energy or power (sum of elements A, B, C & D) depending on which QUAD detector is attached. Take a look at Figure 5 below which includes a brief explanation of many of its features.

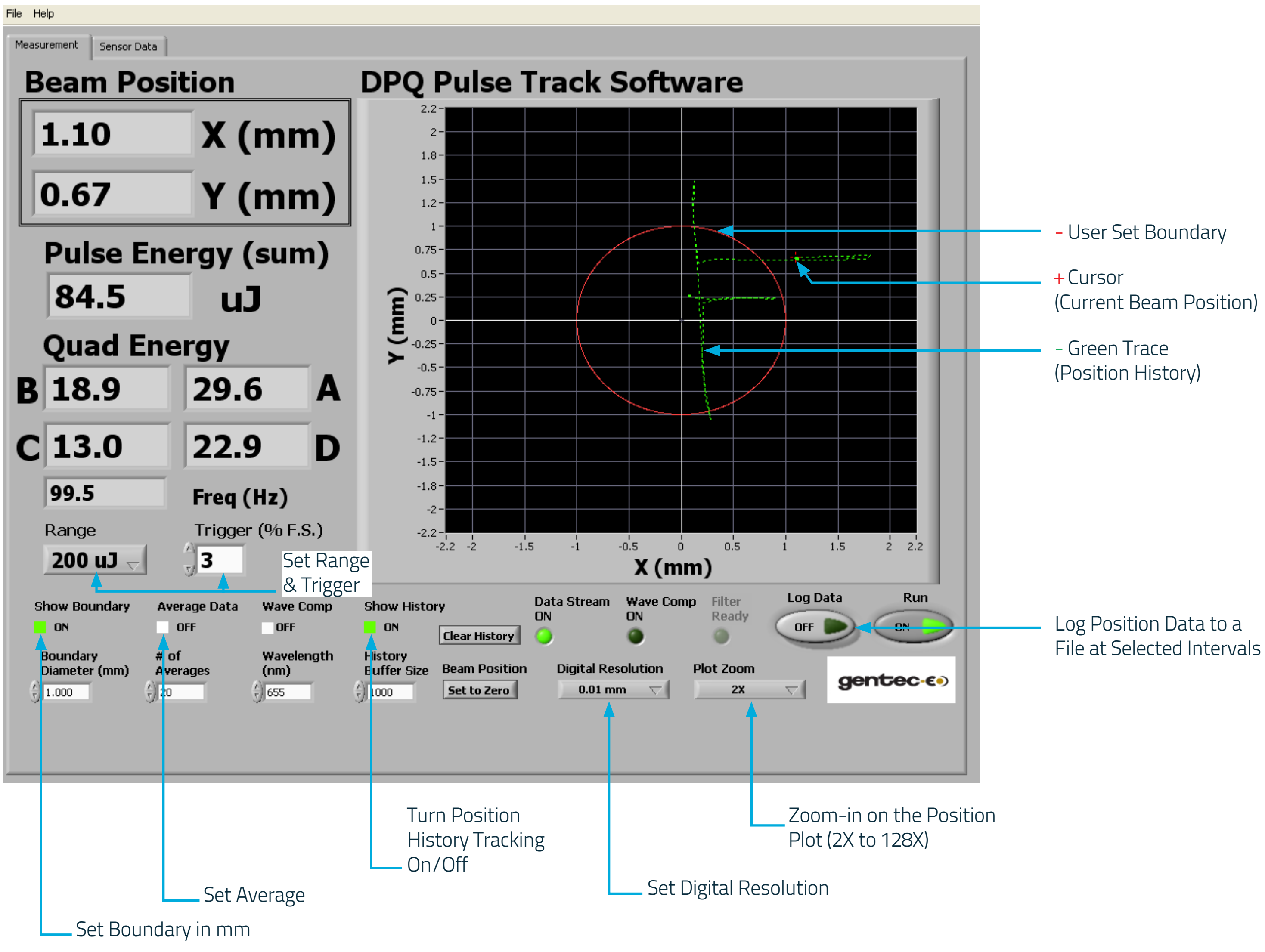


Figure 5: Screenshot of the QUAD-4Track Software.

For more detailed information and specifications on our QUAD detectors and QUAD-4Track Laser Position Monitor, please visit the Position Sensing Detectors product page under the Special Products section of our website and take a look at our QUAD-4Track Video.

You are also welcome to call Don Dooley at (503) 697-1870 or email at ddooley@gentec-eo.com.