Laser Quantum's Noise Measurement:

How Laser Quantum measures and reports

One of Laser Quantum's goals has always been to create lasers with the lowest possible noise.

Intracavity frequency-doubled lasers have an inherent noise of about 3% RMS. Several techniques have been developed over the years to reduce this noise, known as the "Green Problem", and at Laser Quantum we have worked for many years to develop cavity innovations and electronic solutions to progressively reduce the noise level to below 0.02% RMS (Figure 1). Our techniques are applied to all of our visible lasers and many have been patented.

All these advances in noise reduction have made it much harder to actually measure the noise using existing commercial systems, as it is a very small signal. We have, therefore, developed our own system to measure noise accurately.

There are three parts to the noise detection method:

1. The detection
2. The fast analysis
3. The long-term computer analysis

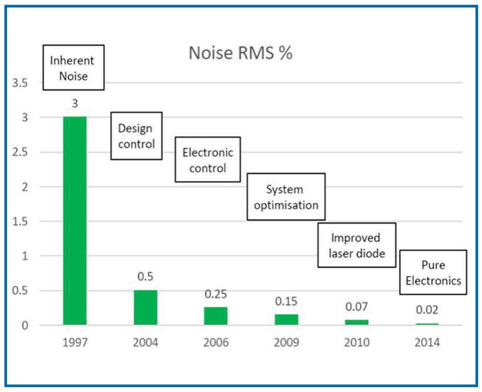

Figure 1: Timeline showing noise RMS optimisation over a 17 year period.

The detection

Our detectors are specially made to measure 100% of the laser's power, with no ND filters or pick off wedges between the laser and our detectors. ND filters placed in the laser beam path can lead to unwanted interference effects which can result in spurious noise contributions.

To attenuate the laser power, we use a specifically designed ceramic plate of a thickness suitable for the measured power that diffuses the laser beam. This reduces its power and removes the need for an ND filter with parallel optical surfaces (Figure 2).

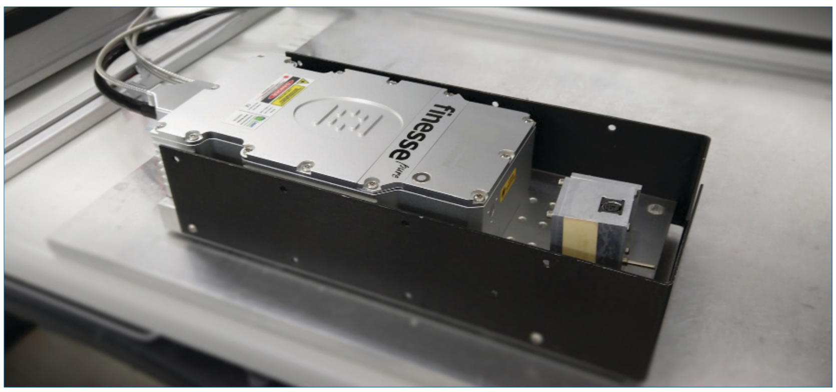

Figure 2: Laser Quantum's finesse pure continuous wave laser.

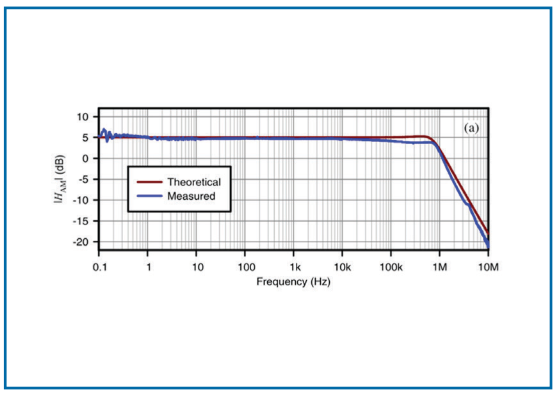

Figure 3: Magnitude of the measured and theoretical complex AM NTF response. Reprinted with permission from OSA[1].

One of the applications for our lasers is Ti:Sapphire pumping. Ti:Sapphire crystals have a noise transfer function: laser noise occurring at frequencies beyond the frequency range of the transfer function is not seen in the output of the Ti:Sapphire laser beam. In the case of Ti:Sapphire, this is ~800 kHz (Figure 3), so it is imperative to minimise the amplitude noise of the pump source below this value.

Behind the front ceramic plate is our photodetector (Figure 4) that has a bandwidth of 6 MHz, more than sufficient for applications like Ti:Sapphire pumping. The photodiode signal is then amplified locally in the detector and a sample is sent to our fast acquisition board every 0.02 seconds.

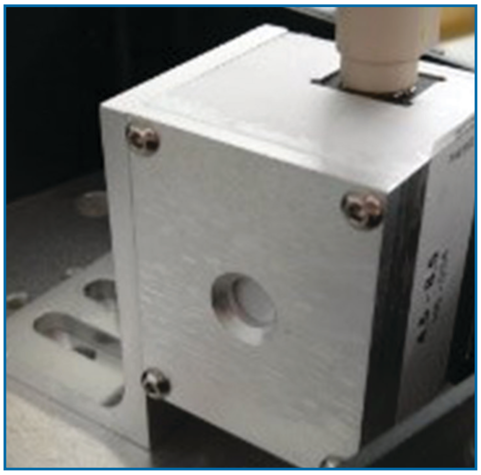

Figure 4: Photodiode used in the laser power detection.

The fast analysis

We have designed our own data acquisition cards that contain a fast data capture board that powers and reads the detector.
The board collates 1024 samples at a time, to calculate average power and RMS % noise.

Figure 5 highlights both the average power and RMS % using all 1024 data points. Peak to peak measurements are measured using two data points and then RMS % is determined over a long test period, allowing any steps or trends in power amplitude to be analysed over many samples to provide a more statistically valid data set.

Long-term computer analysis

The average power and RMS % noise are captured in real time and are also stored for analysis, alongside other key parameters for our lasers.

This burn-in test (Figure 6) is experienced by every production laser for a minimum of 300 hours and will only be passed as Quality Assured when it has met its design specification which is then added to the Certificate of Conformity supplied with each laser (Figure 7).

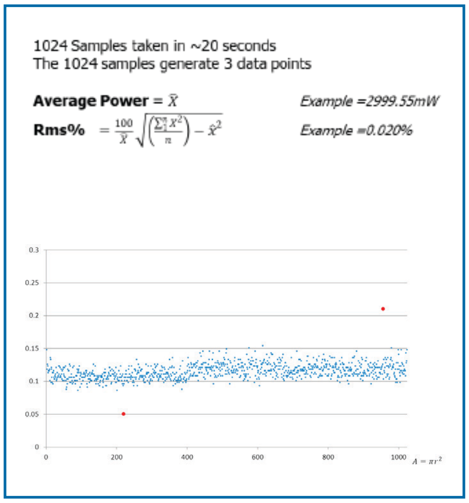

Figure 5: (a) Equations used to generate the data points, and (b) the graph of the 1024 samples taken.

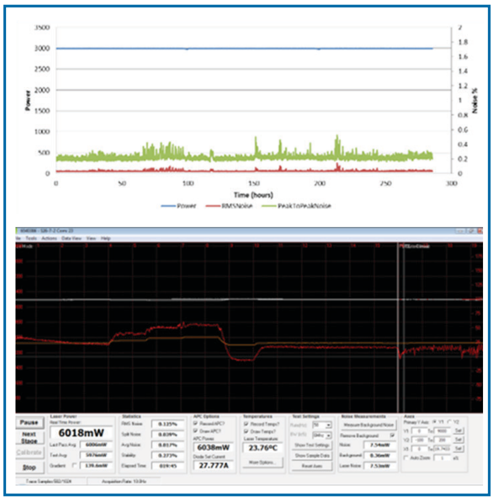

Figure 6a and 6b: Computer acquisition and analysis showing soak test data.

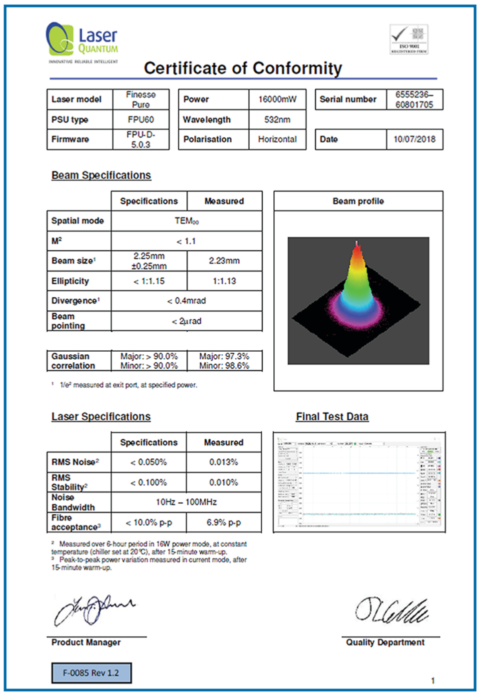

Figure 7: The certificate of conformity provided with each laser, detailing the low RMS noise.