FPAS BOX-CAR INTEGRATOR COMPARISON TO SINGLE POINT SAMPLE ADC ACQUISITION

The FPAS system is a Synchronous Box-Car type integrator with Clear. Simple ADC acquisition systems utilize a single point sample. The advantages of the integrator based system result in a wider dynamic range, lower noise and much less sensitivity to pulse to pulse variations. The integral of a pulse is a much more stable and lower noise representation of the actual pulse energy than a single point sample.

For comparison, the specifications below are presented using a 500 sample acquisition of pulses. The averaging effect of the 500 shots provides the same advantage in both types of systems, and improvement of Signal to noise by a factor of 22.36 due solely to the averaging, assuming the noise is white broadband noise. The Single point sample acquisition system is a system that has an AC coupled preamp, filter and A/D converter. No analog signal processing is provided in the Single point sample system, the acquisition is done by acquiring at a single point on the pulse response profile.

Cabling – The MCT detector is very low impedance and therefore produces very little electronic noise pickup or EMI potential. The 100-200 Ohm impedance of the MCT coupled with the 50 pf cable capacitance produce a frequency pole near 16 MHz, which is far beyond the MCT or electronic responses. The length of the cables does not have an effect due to this low impedance. The cable capacitance, which is very low has a negligible and un-measureable effect on system noise performance. The integrator, by nature, would also average or integrate any residual high frequency noise present. Cable noise effects are typically only present in high source impedance devices.

The FPAS has several advantages over a single point acquisition system and presents superior signal to noise and dynamic range:

FPAS Performance:

Synchronous Box-car type integration provides a single pulse averaging effect to reduce the noise during the signal accumulation of the entire pulse by the integrator. The Single point sample system is subject to the noise phase at the time of the single point sample, and can vary from pulse to pulse.

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The Synchronous Clear function assures that there is no retention of previous signals by resetting the integrator to zero prior to acquisition of the next pulse. The single point sample system can not be fully returned to zero before the next sample occurs due to the integral of the signal pulse being exponentially decayed. This effect is much more prevalent at high frequency repetition rates.

The FPAS system with 500 shots provides a maximum dynamic range of 1.2 E6:1. The equivalent ADC counts of dark noise is 0.0526 Counts of noise. Fully 120 times better than a non-integrating system.

With Maximum gain, the FPAS provides a Signal level of 5.0 Volts and a dark noise of 25 uv. With the full scale signal range of 65536 Counts, the noise would equate to 0.327 Counts of noise and a signal to noise dynamic range of 200,000:1

With Minimum Gain, the noise reduces to about 3 uv bringing the equivalent counts noise to 0.0393 counts of dark noise and a dynamic range of 1.66E6:1.

Peak to peak noise is about 2 Counts with 100 Shots, providing a peak to peak dynamic range of ~32,000:1 and with RMS averaged for 500 Shots the dynamic range increases to 200,000:1.

These pictures were taken of a current system with MCT detector connected prior to final Trim and calibration.

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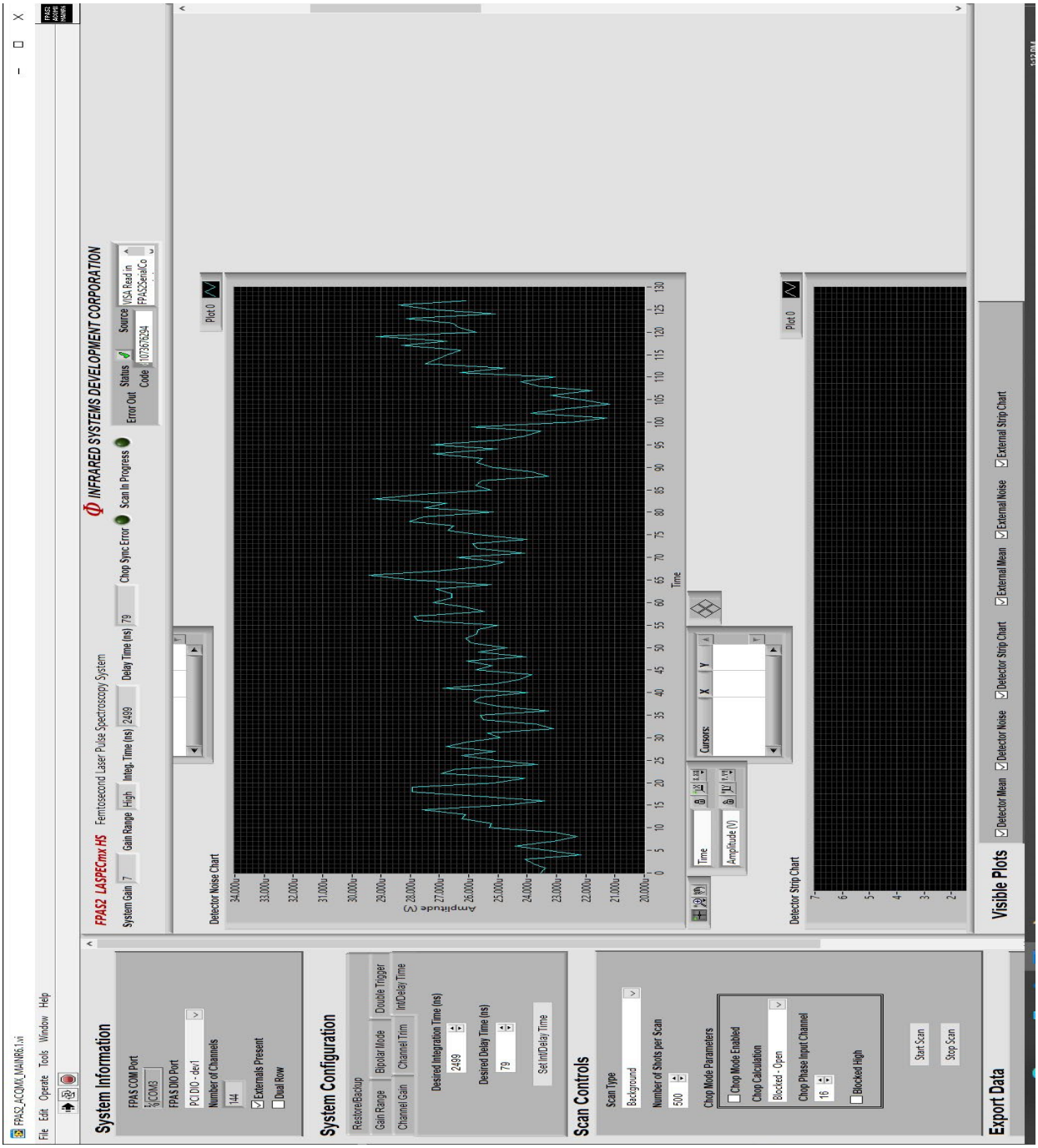
Maximum Gain Noise 500 Shots



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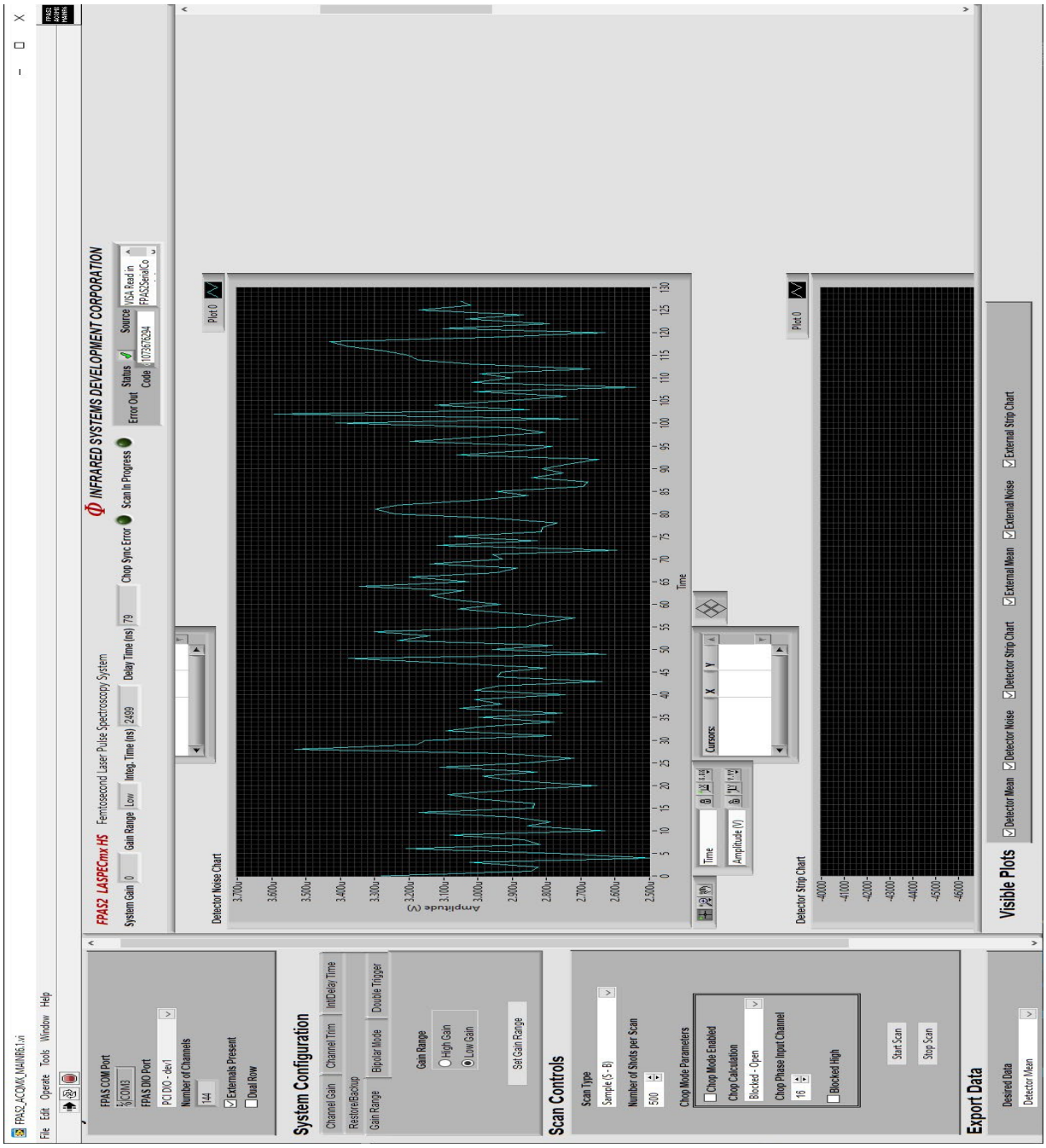
Minimum Gain Noise 500 Shots



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FPAS Integrator advantages:

In real world signal capturing of pulses, the timing error (Jitter) between acquiring a single point on a pulse waveform from pulse to pulse can present a large variation in reported signal.

Since the Integrator acquires the integral of the entire pulse, the timing variation (Jitter) has an insignificant effect of the pulse to pulse timing variation or Jitter.

The Integrator also reduces the effective bandwidth by only accumulating charge during the pulse time. This greatly reduces the noise component while signal is being measured.

The resulting integral is held during A/F conversion to prevent and droop or change in the signal during acquisition.

Synchronous Clear:

The FPAS integrator has a synchronous Clear performed after the A/D conversion to return the pre-integration level back to the baseline. This prevents any retention of previous signals and provides fully independent sampling of every pulse.

The non-integrating system relies on a filter to reduce noise, but this has a long decay time causing the next pulse to start at the resulting decay level of the first pulse. This appears as a reduction in signal level as more shots are acquired.

Baseline Integrator:

During the time that the Integration is not active, the electronic path reverts to a baseline feedback integrator. The acts as a DC restoring circuit to allow the signal integrator to integrate the entire signal pulse without any previous signal retention. This baseline integrator keeps the system baseline (zero level) at a constant value. This is important because any out of interest signal can accumulate and shift the baseline level. This baseline integrator provides the signal integrator with a stable starting point for each new pulse that is sampled. It removes any ambient environment temperature variations and absorbs any signals or noise that is present during the time that the synchronous integrator is not active.

Without a baseline restoration, the integral of any signals will be added to the zero or baseline level prior to signal acquisition. This can cause significant variations in signal acquisition with multiple pulse, radiation background variations and electronic drift.

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Constant Bias Voltage Preamp constant:

MCT detector response is directly proportional to the applied bias voltage. In the single point system, the bias is provided by a resistor divider, therefore, as the signal increases, the bias voltage reduces. This reduction in bias voltage reduces the signal level as the signal increases. This adds to the already non-linear MCT response to large signals producing more nonlinearity.

The FPAS system uses a constant voltage Current-mode preamp to provide constant bias voltage to keep the detector response parameters constant at all signal levels.

FPAS Features:

Other features not found in single point sampling systems are the integration time, gain selections and trim functions. These functions provide limitless variation of the acquisition parameters to optimize the system for a particular acquisition or sample type.
The FPAS has a HIGH/LOW Gain range to provide boosting or reduction of signal gain on all channels. This can be important in setting the proper energy levels from the laser system.

The FPAS also has a GAIN control for each channel. This function allows every channel to operate at it's own gain setting to overcome spectral variations and normalize the response. Channels with very high response can be set to a lower gain to allow the low response channels to have the best signal to noise.

Each channel on the FPAS also has a TRIM selection. This allows the response of each channel to be trimmed accurately to match the response of the other channels. The nature of the MCT detector is that varaiation of response from channel to channel can be 50-70%. This function allows the raw data to be normalized to present a flat response.

Summary:

The FPAS system has been designed to compensate for the various noise sources in a real world infrared measurement setup. The Signal integrator is to average and reduce noise for single pulse acquisition, and uses this advantage to provide better signal to noise in multiple pulse measurements., the Baseline integrator is to keep the baseline stable so each pulse is truly an independent acquisition.

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The selectable integration time provides complete freedom in deciding what port of the signal pulse to acquire. Shorter integration time results in a noise reduction that is directly proportional to the integration gate width. This allows the user to optimize the signal acquisition for a variety of pump-probe and pulsed measurement.

Selectable Gain and Trim for each channel allow every element response to be tailored to the provide resulting spectral shapes that are uniform. And selectable Gain can also be used to set the desired dynamic range to suit the signal energy presented by the pulsed source.

The FPAS Labview software VIs provided allow the end user to insert these functions into their own master software for integrated experiment control and acquisition.

Advanced features include synchronization with an external chopper or other signal path device, Variable Integration Gate width and Delay time for adapting to timing of the energy pulses. Chopped-mode acquisition that allow the system to acquire during both open and closed sections of the chopper, and the ability to measure Bi-Polar signals created by slower energy sources.

External Channels:

The FPAS provides 16 or more external channels for user devices such as chopper sync, Pump status, single detector with or without preamp and DC signal level acquisition. These external channels are acquired at the same time as the array data and can be used for further manipulation of the array data based on the status or signal of the external inputs.

The FPAS offers superior performance in signal to noise, noise rejection, baseline stability and versatility in Gain and Dynamic range. Proven, reliable operation as used in hundreds of labs worldwide.