

## 800L Test Systems --- *leading edge control resolution*

The 2350 Controller provides outstanding high-resolution control and measurement of load, strain and position for micromechanical tests and situations where test requirements push transducer ranges beyond normal limits.

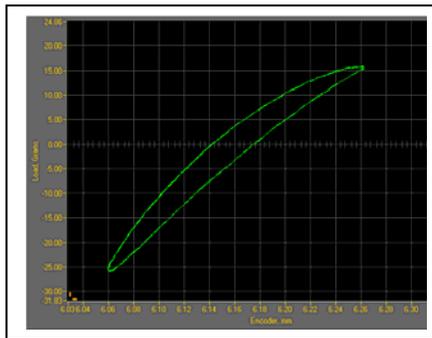
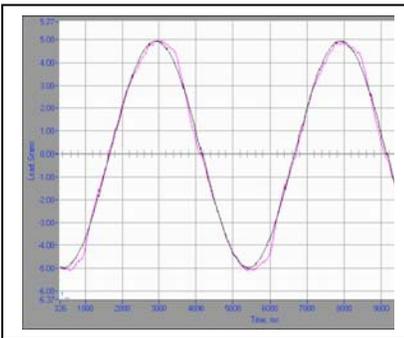
Major 2350 Advantages:

- **New LOW NOISE Conditioners Available** – 2350 24 bit signal conditioners feature amazing low noise floor specifications which extend the systems ability to range down and also to measure and control micromechanical small scale positions and loads. With our system, the ultimate limiting factor of micro machine performance is sensor rating. Controller noise floor becomes very important as well.
  - Examples:
    - $\pm 100$  gf load cells have noise floor of  $\pm 0.01\%$  or better.
    - $\pm 1$  mm travel LVDT noise floor  $\pm 0.2$  micron or better
    - Noise free digital encoders available with 0.1 micron displacement resolution
    - 100 N load cell can be set to 1 N active range to increase resolution hundred fold (100X)<sup>1</sup>.
- **New 24 Bit Resolution Conditioners Available** – Since the noise floor has been decreased, the importance 24 bit resolution increases.
- **Linearization Firmware Polynomial Fit Firmware** – 2350 firmware includes linearization via polynomial fits to improve transducer linearity. Accuracy of 0.01% becomes available.
- **High Resolution Firmware Super Averaging (SAV) Data Pipe** – pseudo real time data averaging is made possible to further reduce noise floor measurements. This feature is used in quasistatic tests (2 Hz and slower) where the data is averaged and noise further reduced by a factor of 5 or more.

What does this all mean?

### Application – Low Force Foam Compression Test

Compression – compression fatigue tests were run on a foam test sample with  $\pm 5$  gf load control amplitude. The load cell was a 1000 gf cell and so a load of 0.5% of full scale was controlled. The system was a model 800LE316 – rated 6 kN (1350 lb).



800LE3 - rated 6 kN with a lower force 1000 gf full scale load cell. The encoder measured position.

<sup>1</sup> By definition, any increase in resolution is accompanied by proportionate increase in noise and drift. Even so, inherent low noise of 24-bit conditioners (down to less than 0.01% of full range) contributes to measurement quality.

## Background discussion

The 2350 Digital Controller includes a high-performance Digital Signal Processor (DSP) that performs real time calculations necessary for direct digital servocontrol. The DSP computes control correction signals to the actuator and performs all machine control activities, including data collection. The calculated value is output to the servodrive as an analog signal at a speed of thousands of times a second (up to 20 kHz if needed). In the case of multiple actuators, that speed drops but remains above the response time of the actuator.

The 2350 makes it possible for any available transducer to provide the servo-feedback, making it possible to perform precise tests under stroke, force, strain or other modes of control. The signal may come in as a high level 10V signal from a customer provided signal conditioner, or it may come from the 2350 signal conditioners.

Overall, the controller test and measurement quality is related to the number of bits per readout with the controller and signal conditioners response time or loop update rate.

Some suppliers of digital controllers claim up to 32-bit control resolution. Servo-out resolution specifications in themselves can be misleading, since you cannot control anything better than you can measure it. Even if you could achieve the impossible, you can't prove so unless you can measure it with the same resolution claimed. That said, resolution remains important when part of a discussion that includes electrical noise.

Resolution specifications define the smallest measurement increment. Twelve bit resolves a transducer to +/-0.05% of a 100% range. Sixteen bits resolves to +/-0.003% of full scale and nineteen bits extends that by a factor of 23, so delivers +/- 0.0004%. It takes 21 bits to resolve one part in a million.

True test data quality is limited by electronic quality, or noise floor of the control system, not the resolution. Resolution bits specified means little unless backed up by matching electronic quality. Industrial and laboratory electronic signals are 10VDC or less and so electronic noise can easily interfere with data. Electronic engineers know how challenging it is to guarantee signal noise less than 5 mV (~ 12 bit resolution). It is a given in this discussion that the sensor has been selected to match the measurement and control bandwidth of interest.

So, unless the signal being measured has noise less than 5 mV, 12-bit measurement resolution is adequate for control output. This constraint is particularly true with strain bridge transducers such as load cells and extensometers which use signal conditioning where bridge output is mV level and then amplified more than 100 times, because noise is amplified 100 times as well.

Research conducted at customer sites around the world on 2350 controllers equipped with our standard 16 bit signal conditioners indicate effective test data resolution of raw data ranges between 12-bits and 16-bits on load cell outputs.

The 2350 employs multiple noise abatement strategies that lower system noise floor:

- 1) OverSampling - Because of the high DSP speed, the controller is able to over-sample data and average the readout (all 8 primary channels). Oversampling is a proven technique within the mechanical test industry because random noise can be reduced by the square root of sample size, or a noise reduction of 64 times at a sample size of 4096. Over-sampling applies to measurement, but cannot be used in the control loop which is updated thousands of times per second.
- 2) Digital filtering, combined with 24-bit measurement hardware, is now available on 2350 Resolution Plus controllers, which improves measurement quality 3 to 8 times better than the 16 bit hardware signal conditioners and 2350 controller. Resolution Plus improves the quality of servo-control and measurement, and is especially important when operating over a small part of transducer range.
- 3) Digital transducers also deliver great quality because they are practically noise-free. A digital linear encoder guarantees zero noise at high (0.1 micron) resolution.