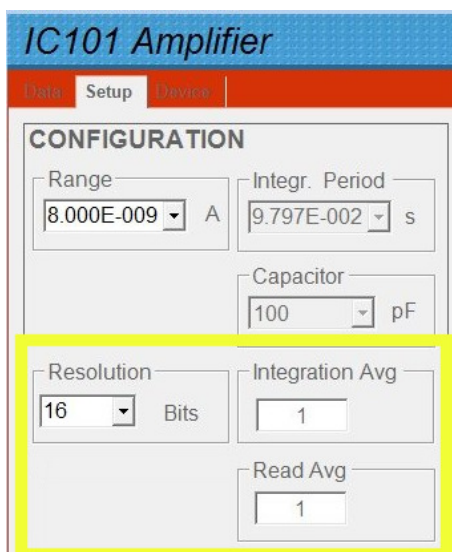


**TN0012**
**Resolution enhancement on the IC101 and I404 electrometers**

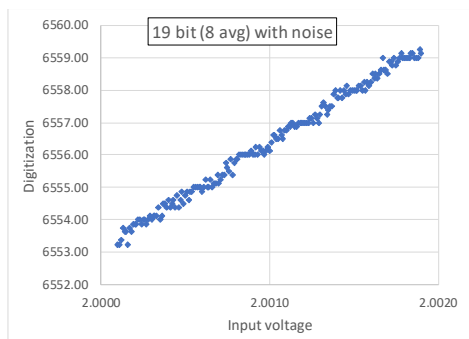
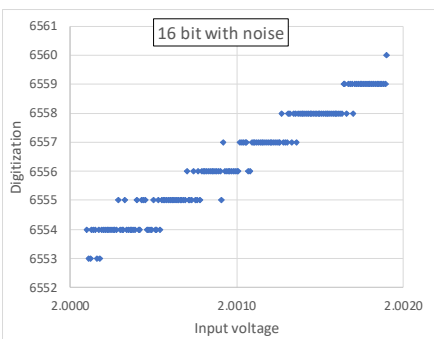
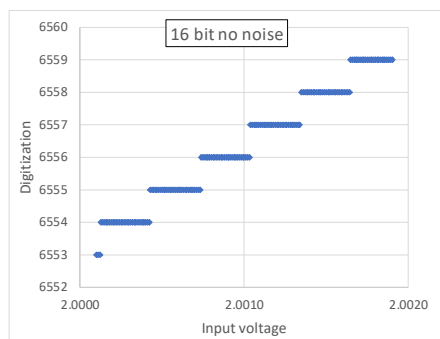
## Resolution enhancement

The IC101 and I404 integrator products allow the user to specify resolution settings from 16 to 20 bits. The method involves the use of two different averaging strategies in combination.

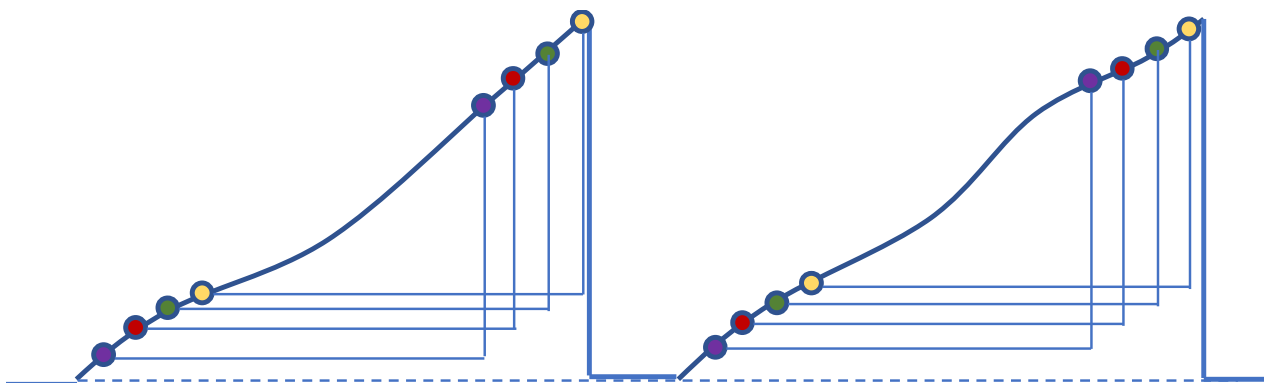


So long as there is random variation in the signal, the averaging increases the effective resolution of each reported measurement. Averaging two analog to digital conversions increases the native 16 bit resolution up to 17 bits, four conversions gives 18 bits and so on up to sixteen conversions which gives 20 bits.

The following plots show a simulation of an analog voltage changing over a small fraction of the range of a 16 bit analog to digital converter. If there is no noise in the signal (a physically impossible signal), then the ADC output jumps discontinuously when the signal reaches the threshold for the next bit. With noise, there is blurring at the transitions, but the digital resolution remains the same. But if we use eight repeat readings for each data point in the presence of noise, then the gaps in the digital resolution are filled and we have an effective increase in the resolution.



The two strategies used to get the repeat readings are integration average and read average. Integration average combines results from multiple integrations as a rolling average. Read average takes more than one start and stop conversion during each integration cycle. The illustration below illustrates the output of a charge integrator over two integration cycles for a case where four ADC pairs are taken for each charge integration. Each start/stop ADC pair is separated by the known fixed integration time. Then results from two integrations are then combined to give a total of eight values which are averaged to give effective resolution of 19 bits. The IC101 or I404 selects the optimum combination of the two strategies according to the selected current range.



## Noise reduction

Because the resolution enhancement feature uses averaging methods it reduces the amount of random noise in the data. The following plot shows the measured standard deviation of the signal for an I404 input connected to a miniature ionization chamber via coaxial cable for the standard current range selections. The 20 bit setting shows lower noise for all range settings.

