

TN0013

Measuring accumulated charge on I-series products

Charge measurement limits

The maximum amount of charge that can be accumulated in a single integration in an I-series electrometer product such as the I400, IC101, I404 or I3200 is limited by the size of the integrator feedback capacitor C_{fb} and the maximum conversion voltage V_{ADC_max} of the ADC that measures the integrator output.

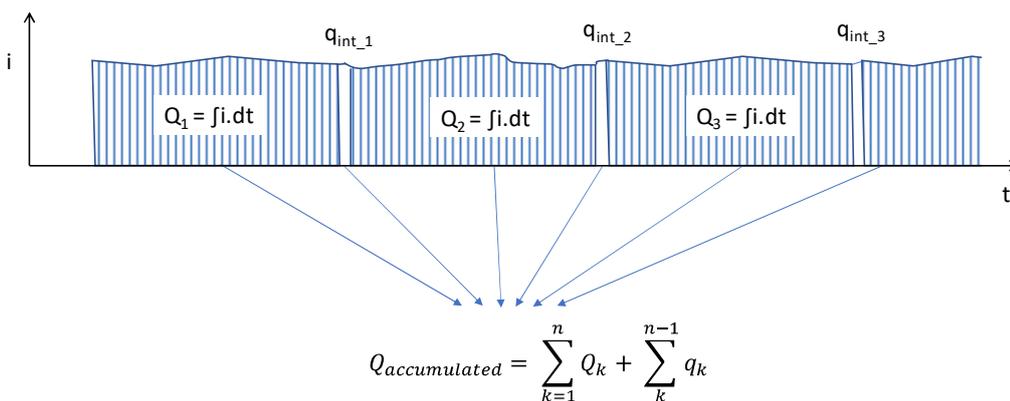
$$Q_{max} = C_{fb} V_{ADC_max}$$

V_{ADC_max} is 10.0 V for Pyramid integrator products, and the overrange flag is set at 9.8 V. The nominal 10 pF feedback setting of the I400 can therefore measure up to about $10e-12 * 9.8 = 98$ pC before overrange. The actual value depends on the exact value of the capacitor.

A larger charge can be measured on a larger feedback capacitor, but this is at the cost of reduced sensitivity, and there is still a limit.

Charge accumulation over multiple integrations

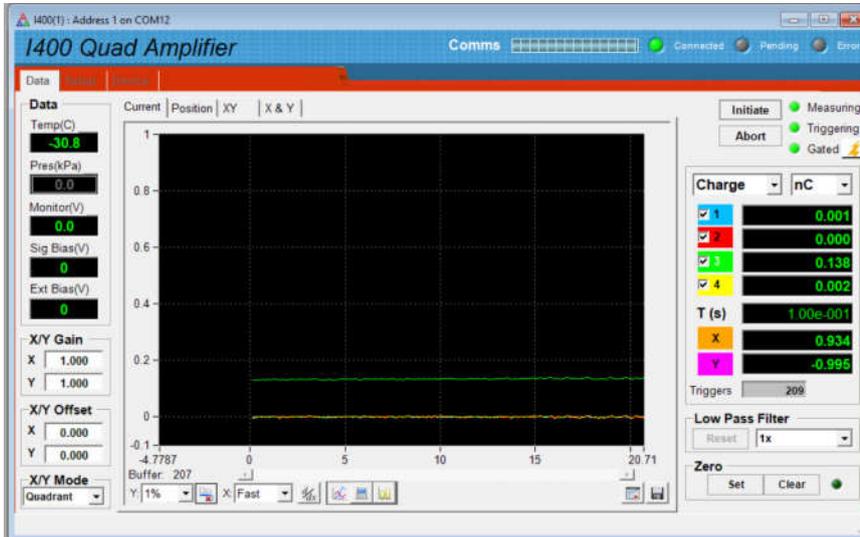
The limitation to the maximum charge limit is overcome by summing the readings from multiple integrations. This can be done by the electrometer, and there is then no practical limit to the charge that can be measured. There is a small deadtime between integrations while the integrator gets reset which must be taken into account. An interpolation (estimation) calculation computes the missed charge based on the prior integration and adds it to the total. If the integration period is 5 msec or more, the amount of correction is very small.



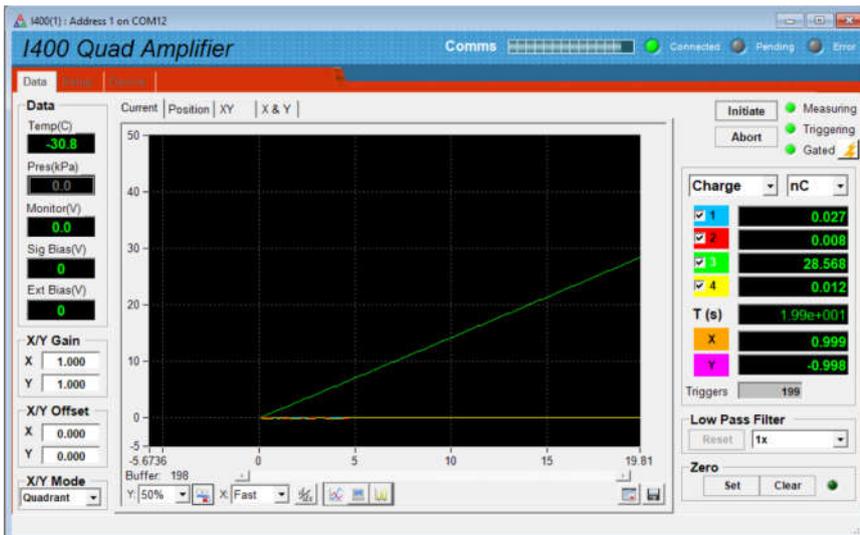
Using charge accumulation mode

The effect of turning on the accumulation mode can be seen directly in the graphics of the PTC DiagnosticG1 software. The screenshots below show the plot of charge against time for an I400 measuring the output of a photodiode on channel three.

Charge accumulation off:



Charge accumulation on, estimated correction of missed charge:



The mode can be accessed via the ASCII command interface. The example I400 terminal session below shows charge measurements firstly without accumulation and then with accumulation turned on for a specified number of integrations. The progress of the accumulation can be watched by repeated `fetch?` and `trig:count?` queries. When the accumulation is complete, the trigger count stops increasing and the values returned by `fetch` are fixed.

Do not use the `read?` command for charge accumulation because it forces an initiate on each use and so resets the accumulation.

```

COM1 - PuTTY
*idn?
  PYRTECHCO,I400-REV3,0000054321,4.0F/1.4.2
conf:cap 0
  OK
period 0.02
  OK
conf:accum 0
  OK
init
  OK
fetch:charge?
  2.0000e-02 S,1.7549e-14 C,-3.5204e-15 C,2.2489e-11 C,-1.4188e-14 C,0
fetch?
  2.0000e-02 S,1.4039e-14 C,-2.4643e-14 C,2.2432e-11 C,-2.8376e-14 C,0
fetch?
  2.0000e-02 S,7.0197e-15 C,-3.8724e-14 C,2.2514e-11 C,-3.1923e-14 C,0
fetch?
  2.0000e-02 S,1.4039e-14 C,-2.8163e-14 C,2.2482e-11 C,-3.1923e-14 C,0
abort
  OK
trig:points 1000
  OK
conf:accum 1
  OK
init
  OK
fetch:charge?
  6.6600e+00 S,4.4575e-12 C,-5.8333e-12 C,7.5041e-09 C,-8.0553e-12 C,0
fetch?
  1.2460e+01 S,9.0624e-12 C,-1.0695e-11 C,1.4046e-08 C,-1.4124e-11 C,0
fetch?
  2.0000e+01 S,1.4257e-11 C,-1.6511e-11 C,2.2557e-08 C,-2.1651e-11 C,0
fetch?
  2.0000e+01 S,1.4257e-11 C,-1.6511e-11 C,2.2557e-08 C,-2.1651e-11 C,0
trig:count?
  1000
  
```

Accumulation turned off

Each charge reading is independent

Set number of integrations to accumulate. Here we have 1000 * 0.02 seconds, so twenty seconds total (plus resets)

Turn on accumulation in estimated / interpolation mode

Charge readings show accumulation on ch 3

... until the pre-set number of integrations are complete ...

... as verified by the trigger count