i404 performance report, addendum
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Introduction.

An earlier report was offered (May 2012) to the vendor and manufacturer of i404 product providing performance data from field experiences, mainly limited to the RS232 interface. This addendum is provided to capture additional observations from extension of application to integration with a counter.

Environment.

The work is performed at endstations of 3rd generation synchrotrons worldwide. The i404 is used to measure current from photodiodes positioned in a range of strategic positions during the alignment, commissioning and operation of cutting-edge x-ray optical systems.
The counter used was Hytec 8512 IP scaler.
The controls interface used was EPICS. An epics ioc was modified to meet most of the needs of the applications at hand. Since the original report was distributed, features were added to the epics ioc which allow easier setting of line frequency and observation of over-range condition. Polling rate was 2 Hz.

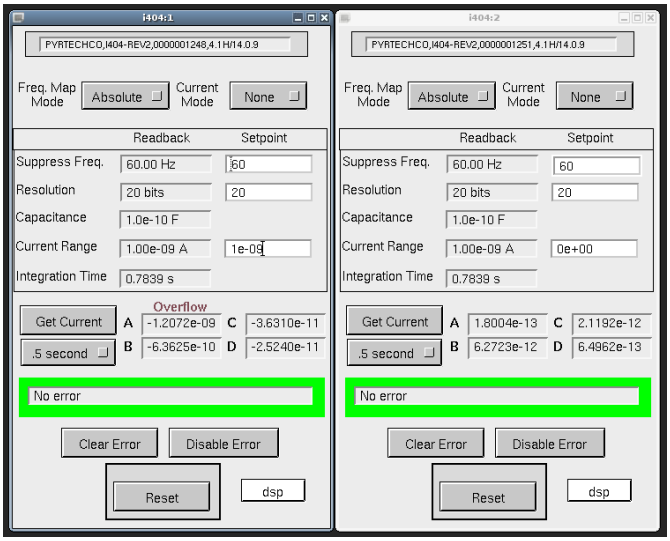


Fig. 1. Eight photodiode channels monitored via EPICS EDM interface. Overflow condition is reported on channel 1A.

Observations.

1. RS232 data is roughly 20x noisier than TTL signals captured with counter. Noise level of 50 cps (50 pA) was achievable at 1E-6 range, compared to 1 nA noise level as reported from the RS232 interface. This suggests that higher resolution is available (up to 14 bit) than is being reported via the RS232 interface (roughly 10 bit). Periodic noise appears more prominently on RS232-readback values, further suggesting environmental noise may be getting picked up at the digitization stage.

2. RS232 readback values are delayed by 2-3 seconds. This is essentially intolerable for any realistic system. Response time should be less than 1 second or 0.5 seconds. Typical scans dwelling 0.5 or 1.0 seconds per point

show apparent offset in position corresponding to this delay and can lead to erroneous positioning based on the RS232 readback value.

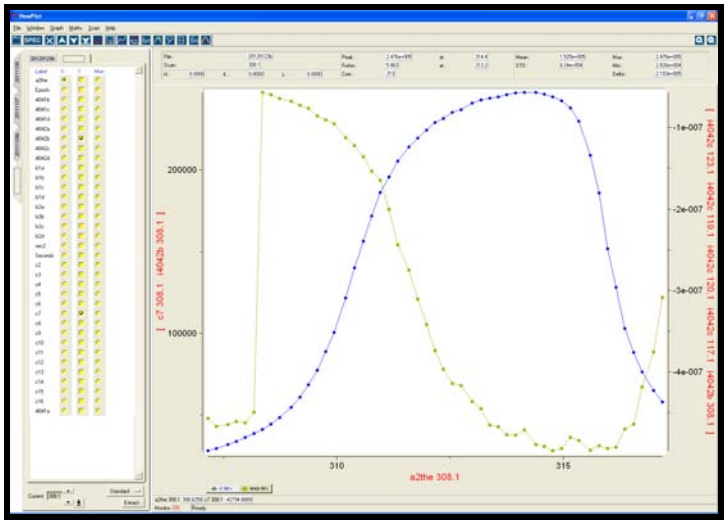


Fig. 2. Example scan. Counts per 0.5 second (left y axis, data in blue) and i404 readback current (right y axis, data in green) versus a scanned position axis. Data collected at SPring-8 synchrotron (line frequency 60 Hz) with 2E-6 A range. The diode was wired in inverted fashion for compatibility with Keithley inverting current amplifiers and positive voltage input voltage-to-frequency converters; the i404 frequency mapping mode was "absolute" so that positive frequencies were generated for negative currents. Noise level and readback delay are evident.

3. Frequency mapping does not handle bimodal or offset current elegantly. In many environments there can be a background level with opposite sign as the signal of interest. Without a current offset or bimodal frequency mapping, data from the TTL output of the i404 is difficult to interpret.

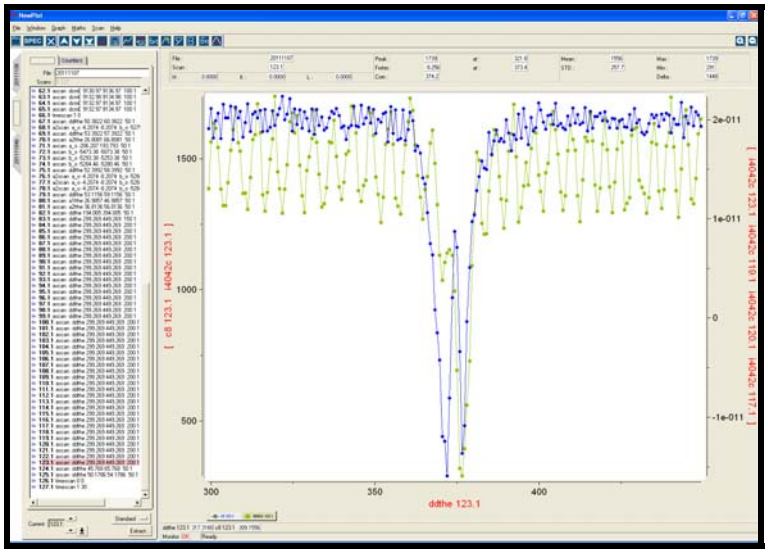


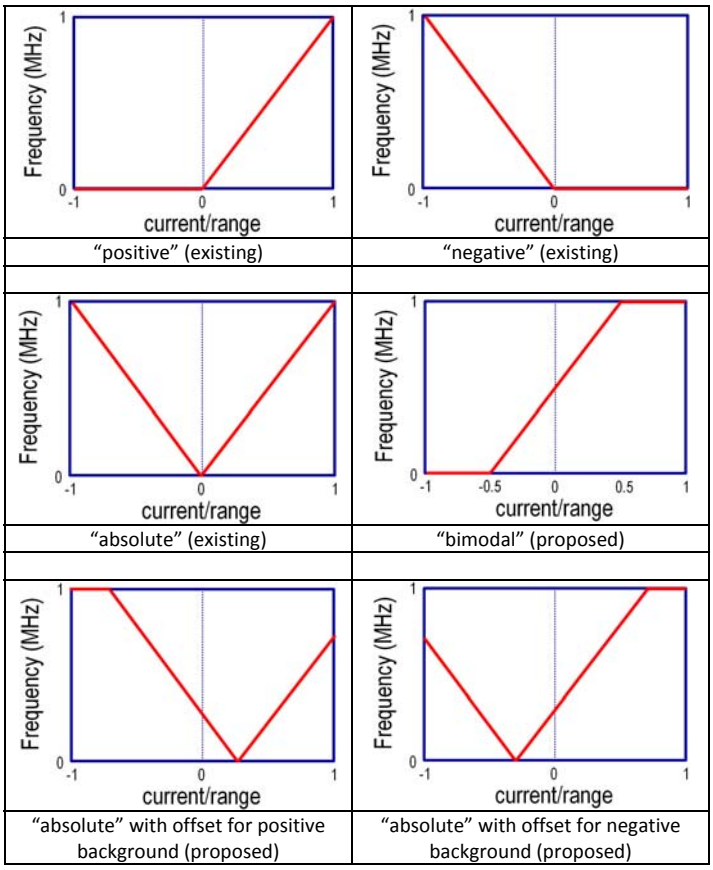
Fig. 3. Example of a negative peak on a positive background (RS232 current in green/RHS, TTL counts blue/LHS). When the net signal is negative, the peak folds upon itself in "absolute mode". Data collected at Petra-III/P01 (line frequency 50 Hz). Selected range is 1E-8 A.

Conclusion.

The i404 serves well as a current integrator but lacks high-quality digital interface. Digitization of the current signal to RS232 is poor compared to TTL output available.

Suggested improvements include (in addition to those listed previously):

- Integrated counter
- Bimodal and/or zero offset capability in frequency mapping.
    1. Current offset approach will be most familiar to former users of Keithley 428. An offset current in A would be supplied by the user and applied to a mapping profile similar to "absolute" mode. This parameter may need to take a value of up to ± 20% of the selected range (both negative and positive offset currents should be allowed). Between the two solutions suggested here for dealing with bimodal signals, this one is preferred for the application described above.
    2. Bimodal frequency mapping may be more universally useful and require fewer adjustable parameters, although it creates a non-zero countrate for zero current which can introduce confusion in the interpretation of results and errors for some applications. A possible "bimodal" mapping is shown below which preserves the 1 MHz per selected range calibration ratio.



"positive" (existing) | "negative" (existing)

"absolute" (existing) | "bimodal" (proposed)

"absolute" with offset for positive background (proposed) | "absolute" with offset for negative background (proposed)

- Improved digitization integrity available via RS232 or Ethernet, to attain true 16-20 bit resolution/noise and < 0.5 second readback delay.
- Ethernet interface strongly preferred (vs. RS232).
- Improved API
    - Line frequency and detector bias password protection should be removed, and/or boot-up defaults changeable for regional installation