

## EXTENDED MICROIOC FAMILY (LOCO)

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### Abstract

MicroIOC is an affordable, compact, embedded computer designed for controlling and monitoring of devices via a control system (EPICS, ACS, and TANGO are supported). Devices can be connected to microIOC via Ethernet, serial, GPIB, other ports, or directly with digital or analog inputs and outputs, which makes microIOC a perfect candidate for a platform that integrates devices into your control system. Already over 90 microIOCs are installed in 18 labs over the world. Logarithmic Converter (LOCO) is a specialized microIOC used as a high-voltage power-supply distribution system for vacuum ion pumps. A single high-voltage power-supply controller can be used for delivering power to multiple ion pumps. A highly-accurate logarithmic-scale current measurement is provided on each pump, enabling an affordable and reliable pressure measurement ranging from  $10^{-12}$  to  $10^{-4}$  mbar.

### INTRODUCTION

Products in the microIOC family [1] provide a wide range of solutions for particle accelerator facilities. The products cover controllers for interfacing serial devices, motion controllers, controllers for processing analog, digital or video signals, beam position and beam loss monitoring systems, timing systems and with LOCO also high-voltage distribution systems. All products are plug & play solutions that can be customized to user needs and can be directly integrated into the control system.

Vacuum in particle accelerators, especially in storage rings needs to be sufficiently low not to reduce beam life time. Vacuum below  $10^{-9}$  mbar in storage rings is achieved with several hundred ion pumps with a total pumping power of tens of thousand liters per second.

Ion pumps are connected to high-voltage (HV) controllers, which not only provide power, but also measure current running through the pump. From the current, pressure inside the pumps can be determined [2], which allows the pumps to be switched off if the pressure is too high to avoid pump damage.

Depending on the controller model, a single HV channel can handle pumps with the total size of 500 l/s to 1500 l/s. Ion pump sizes used in the accelerator facilities range from 20 l/s to 500 l/s with the largest number of smaller pumps. Often HV splitters are used to allow connecting a larger number of pumps to a single channel. Since the average pump size is around 100 l/s, the number of HV controllers is decimated, thus reducing the costs by a factor of 2 – 4 and gaining a lot of rack space. By using splitters the current going through individual pump can no longer be determined and the pressure measurements and machine protection capability of the controller is lost.

Logarithmic Converter (LOCO) is a HV splitter that can be connected between any commercial ion pump controller and up to 16 ion pumps. It measures current going to every pump and also provides cable interlock capability. Using LOCO allows connecting a larger number of ion pumps to a single controller HV channel without losing current measurement or interlock functionality. Since this functionality is incorporated into LOCO, controllers without this functionality can be used.

### DESIGN

#### LOCO Unit

LOCO is a 19" rackmount HV distribution case with up to 16 modules (Figure 1). Modules have high voltage part, where the voltage is supplied to the pump and the current is measured, and a low-voltage part where the data is processed and transmitted to the control system. HV parts of all modules are enclosed in the isolation box positioned in the casing centre, while low voltage parts are turned towards the casing sides. The isolation box is split into two parts, allowing half of the modules to be at one HV level and the others at another.

HV is supplied to the unit over two FISCHER D105Z049 connectors, while it is distributed to the ion pumps via FISCHER D 105A049 connectors. All connectors are mounted on a back-panel with cable interlock connections. The device is controlled using a RS485 serial communication.

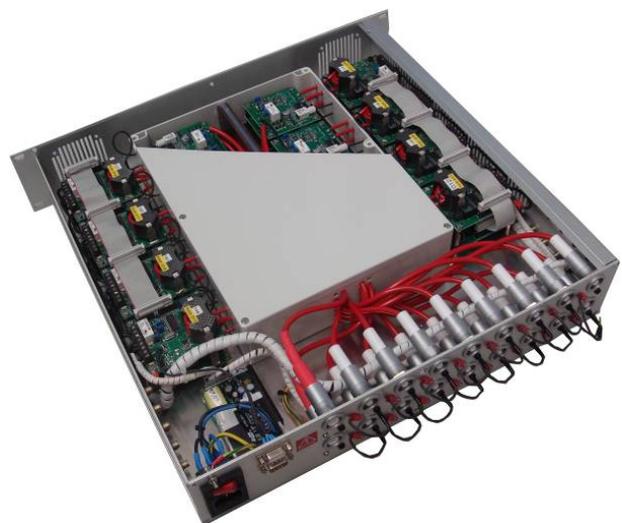


Figure 1: A view inside LOCO.

### LOCO Module

LOCO is essentially an aggregation of LOCO modules. Every module has all the functionality required for an individual ion pump.

HV enters the module (Figure 2) via ‘‘Graetz’’ rectifiers with additional protection to protect further blocks from being damaged by over-current or direct current. Using the rectifiers allows connection of positive and negative supply voltage.

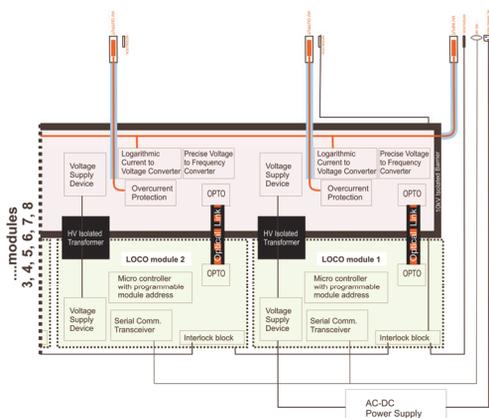


Figure 2: LOCO module schematic. HV areas are marked with yellow colour.

Precise Logarithmic Current to Voltage Converter is used to logarithmically convert current to voltage. The voltage is then converted to frequency. Due to precise temperature compensated electronics, the current is measured with 5 % precision in the range from 100pA to 10mA.

Optical link is used to transfer data from the HV part to the microcontroller, which is in the low-voltage part. The microcontroller is used to communicate the measured frequency and alarm conditions to the user and to trigger interlocks if the frequency is outside the user determined values.

Interlock block has a relay which opens if the interlock cable is not grounded on the pump side. The relay can be opened also by the microcontroller if pressure is outside the desired limits. Interlock blocks are connected in a serial fashion, meaning that interlock of any pump triggers powering down of HV power supply.

### LOCO SOFTWARE

Serial communication over the RS485 line is used to communicate with individual modules which all have unique addresses. Measured frequency in one second, 10 second average, minimum and maximum frequency values, board temperature and status indicating current out of range, HV failure or cable disconnection can be monitored. The user can set minimum and maximum frequency alarm limits.

EPICS [3] support was written to allow direct integration into control system. Values received from

LOCO in frequency units are converted to current and pressure values using the following equation

$$I = Kp^n, \tag{1}$$

where  $I$  is current,  $p$  pressure and  $K$  and  $n$  are constants depending on the pump and applied HV. Values of  $K$  and  $n$  for several ion pumps were determined in collaboration with ELLETRA.

User interfaces written in EDM [4], WebCA [5] and java using the Caj library [6] exist to allow remote monitoring of the LOCO devices.

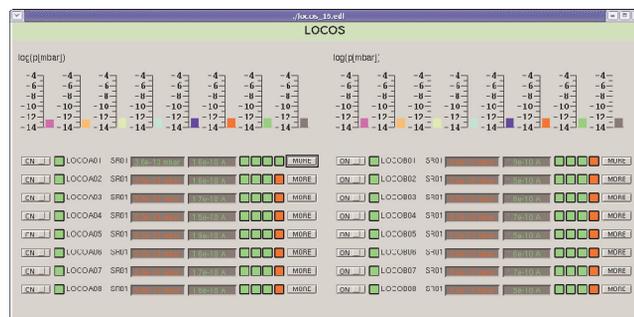


Figure 3: EDM LOCO operator interface

### A REAL CASE EXAMPLE

Let us take SLS storage ring vacuum system as an example. Since the storage ring is divided into sectors, it is prudent that also the vacuum system uses the same division. In section 3 of the storage ring there are 12 75 l/s and 8 300 l/s ion pumps.

If every ion pump is connected to a single Varian Dual controller channel, 10 controllers are required. The price of such a system is around 40 kEUR and 20 U of rack space is required. If LOCOs are included in the system, only two Varian Dual controllers and 2 10 channel LOCOs are required. The price in this case is 15 kEUR and the devices take up only 8 U of rack space.

### CONCLUSIONS

LOCO is an ideal device for vacuum systems where a large number of relatively small ion pumps are used. Its use enables connecting a larger number of ion pumps to a single HV controller channel.

When ion pumps are directly connected to the controllers, the price per pump is from 1500 EUR to 2500 EUR and 1U of rack space per pump is required. If using LOCO the price per pump can be reduced to 300 EUR and the rack space to 0.2 U per pump.

Unlike normal HV splitters, LOCO measures pressure at every pump and provides interlocks to protect pumps from being damaged by poor vacuum.

Test measurements at ELLETRA have shown that the current measured with the Varian Dual controller and LOCO agree within 5 %. The measurements also showed that the relation between current measured with LOCO and pressure measured by a pressure gauge in equation

(1) is accurate within 5 %. This means that also LOCO pressure readings can have the same accuracy, since the  $K$  and  $n$  values can be set for every pump separately. The accuracy of pressure measurements with Varian Dual controller in our tests was around 40 % which is mostly due to generic values of  $K$  and  $n$ .

LOCOs are already used at ANKA, PTB, INFN-LNL and are being tested at ESRF.

## REFERENCES

- [1] <http://www.microioc.com>.
- [2] Giacuzzo, F.; Miertusova, J., " Total pressure measurements in the Elettra storage ring according to the performance of the sputter-ion pumps", PAC 95, p.2042.
- [3] <http://www.aps.anl.gov/epics/>.
- [4] <http://ics-web1.sns.ornl.gov/edm/>.
- [5] <http://webca.cosylab.com/>.
- [6] <http://caj.cosylab.com/>.