

Motors Controller with Optical Interface

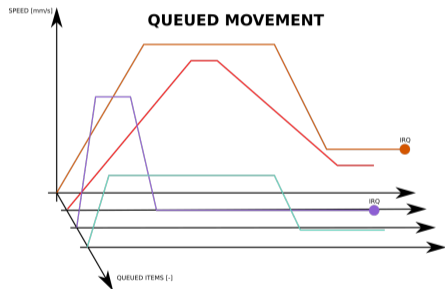
current state of the project

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Architecture overview

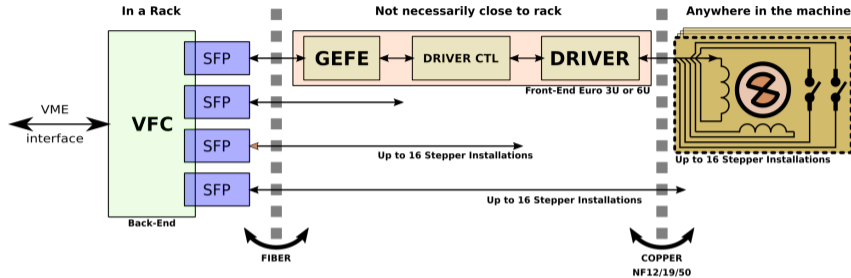
Motors Controller with Optical Interface is a **concentrator** allowing to simultaneously drive up to 64 stepper motors.



- Single motion defined in 4 phases: Acceleration, Cruising at high speed, Deceleration, Trailing at low speed
- Motion queuing
 - 64 commands can be queued for sequenced execution
 - started by SW or by external trigger
 - IRQ generated only when particular motion enables it

Interlock between motors possible: e.g. not starting motion of particular motor if another one is not in given switch position. Tech paper [here](#).

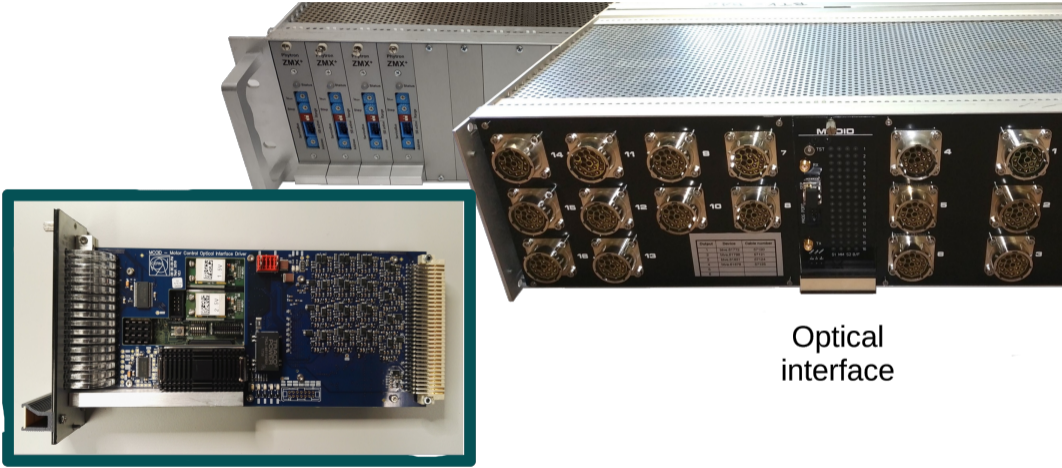
Architecture overview



MCOI is implemented as 2-level system:

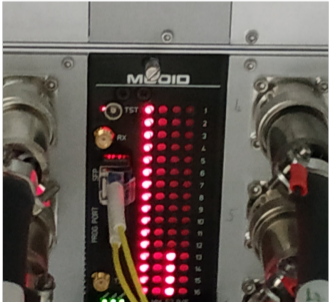
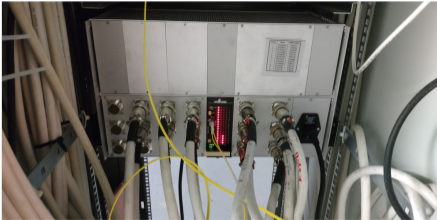
- MCOI front end:
 - Europa 3U or 6U crate equipped with GEFE-based motors controller
 - up to 16 motor drivers can be installed
 - each stepper can be associated with 2 extremity switches
- Back-end based on VFC equipped with up to 4 optical links

Photo - Back-end



Optical interface

Example installation for L4 BWS



Motors and MCOI systems deployed

Following table summarises number of motors currently deployed in the accelerator complex:

Machines	Equipment	Installations	Number of motors
SPS	BTV	5	12
SPS	SEM	3	45
SPS, L4, LBE	SEM + BWS	6	29
LHC, SPS	BSRT	3	112
CLEAR	various	2	27
LAB	LAB	1	~20
		20	248

Possible other upgrades in PM section:

- Eugenio: AWAKE (~3 systems/33 motors)
- Enrico: BSRT installation in LS3 (one crate at CHARM for tests, then 'huge amount of motors', some ISOLDE motors still on MIDI due to lack of GEFE+MCOI)
- Michel: SEM grids in BA80/BA81: additional at least one complete chassis per site
- Stephane: possibly BA7
- Jonathan: ≈ 8 motors through LHC/SPS/PSB + lab mockup

Spares

I took over the project in 2018 when I came to PM section.

- Originally received 25 GEFEs from Andrea to do initial migration of old MIDI controllers to the GEFE based system.
- 20 of them were deployed during the installation in 2019/2020.
- 4 of them hw problems: GBTX or FPGA could not be programmed

At the end of 2020 all systems installed, **no spares left but one.**

Seeing the GEFE situation in 2019 I made proposal for upgrade MCOI to remove GEFE dependency, and to hire a technical student to bring at least prototype.

In January 2021 Andrea/Manoel kindly provided 17 additional GEFEs, which could be used as hot-spare.

At present we have 4 full motor controllers (to be still tested), 13 GEFEs, 2 chassis, 4 VFCs (old-type) cards.

New prototype

Goals:

- **first stage:** direct replacement of actual GEFE + driver controller to have additional spares for current systems and provide newly installed systems with the same architecture.
- **second stage:** embedded linux and being able to drive the motors through the ethernet socket, not needing any more the VFC. Useful for small systems, laboratory equipment.

It was decided to go the easiest solution:

- replace GEFE by Enclustra XU5 SoM, re-routing the driver controller to work with SoM instead of GEFE

XU5 SoM



- Xilinx Ultrascale+ architecture: ARM CPU(s) + large FPGA + DDR4 + Gbit Eth
- Industrial module, 10+ years guarantee of availability
- XU+ is nowadays adopted as well by experiments for data collection → wide CERN support

Where we are with development

Since June 2019 a technical student was supposed to bring **first stage** into a prototype.

Delayed due to COVID:

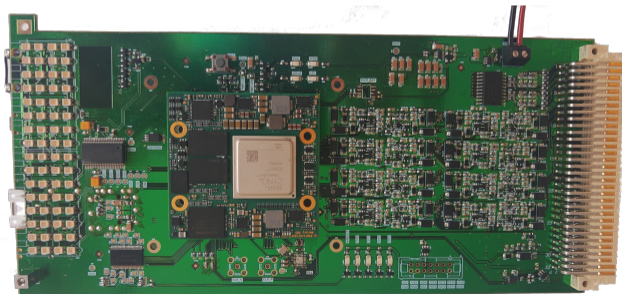
- all PCB manufacturing delayed by 4+ months
- lack of components
- CERN on telework

The first prototype came to CERN after the TS left CERN and there was no manpower to continue the development.

MCOI using SoM

Changes wrt original:

- connection to GEFE through FMC replaced by SoM
- added ethernet port for direct communication with CPU of SoM
- power supplied modified to power SoM



Budget required to finish the first stage

- ~10kCHF: mainly components, SoM modules and production of updated version of the system.
- if manpower allocated we could bring the first prototype within 6-8 months (if all works well and e.g. components are available!)

FOR THE MOMENT THE PROJECT IS ON HOLD

... no new clients accepted, only 'maintaining' what we have.

... since SY-BI reorganisation unclear whether a manpower should be invested into further developments.

Conclusion

- currently we run ≈ 250 motor instances on the system
- possible additional ≈ 100 motor instances could be installed if enough spares
- running out of spares, but still possible to assemble additional 13 MCOI heads

- new development on hold:
 - no budget
 - no manpower

THANK YOU FOR YOUR ATTENTION

Spare slide - per-installation cost

(based on already paid invoices → current price increase not taken into account)

VFC back end + SFP + fiber	≈ 1500CHF	one per installation
MCOI without GEFE	≈ 900CHF	up to 4 per installation
GEFE	1000CHF??	up to 4 per installation
back-end 3U/6U crate without driver	≈ 1300CHF	up to 4 per installation
ZMX+ motor driver	≈ 400CHF	up to 16 per 3U/6U crate