Highly optimized and decentralized motion and sensing control

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ABSTRACT

Recent development of highly integrated electronic devices becomes a possible concept of highly optimized and decentralized controllers. Their optimization concerns mainly energy loss but also deep miniaturization and will allow their decentralization and placing closely to the controlled equipment as motor, sensor, etc. That will lead to a drastic reduction in wiring, weight and simplification of installation. Installation of new communication technologies such as CAN bus, Ethercat etc. will allow to maintain also high parameters. The proposed modern design grouping into one: MEZZ interfaces to external sensors, CPU based on 32-bits DSP and reprogrammable CPLD but also power electronic allows for wide possibilities of remote diagnostics and adaptation to a given application.

Keywords: Highly integrated electronics, distributed approach

1. INTRODUCTION

Following our previous projects, and especially with the recent development of highly integrated electronic devices becomes possible a concept of highly integrated, optimized and decentralized controllers. Their optimization concerns mainly energy loss essentially in the power electronics' part but also their miniaturization and easy installation. Minimizing energy losses will allow decentralization of electronics and placing them closely to the controlled equipment (motor, sensor, etc.) or in some cases integrate electronics with actuator or sensor. That will lead to a drastic reduction in wiring and, at the same time, reduction of weight and simplification of installation.

2. WHY HIGH INTEGRATION?

The Most popular control systems are based on the inter-connection different elements and modules where each part provides a single function as Power amplifier, CPU, A/D and D/A conversion, digital I/O etc..

2.1 Critical analyze

In this case the electrical connections structure are quite complex. Knowing that power amplifiers are separated from the control sub-system, the high-resolution analog inter-connections need to be **carefully designed** and implemented. As a consequence, distance, **grounding and resolution** become critical.

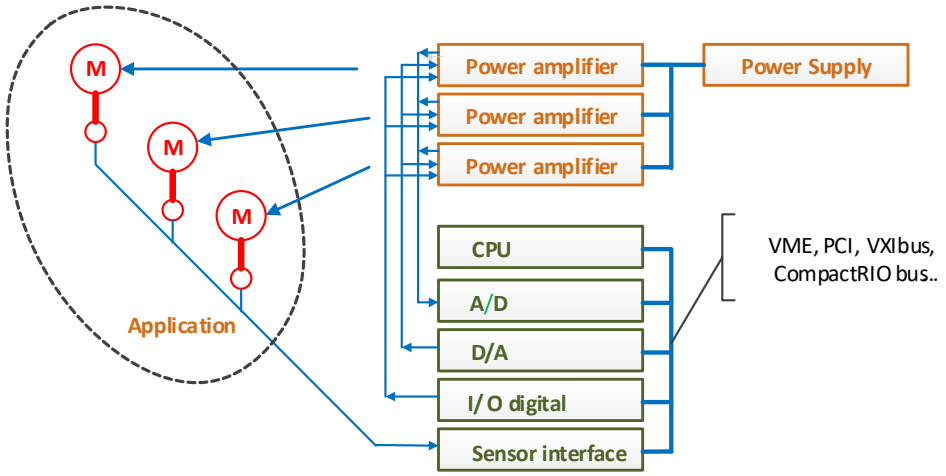


Figure 1. Most popular centralized control structures

This configuration reveals several disadvantages:

1. Complex electrical inter-connection including high-resolution analog cables
2. Unique design and increased price.
3. Distance, grounding and resolution become critical.
4. increased EMC sensibility.
5. Relatively complex maintenance and manufacturing time
6. Many connectors leading to low reliability.

2.2 Integrated solution (all in one unit for one actuator/sensor)

The interesting alternative against a centralized configuration is proposed highly integrated solution based on the modular design, distributed intelligence concept and applying new generation of devices.

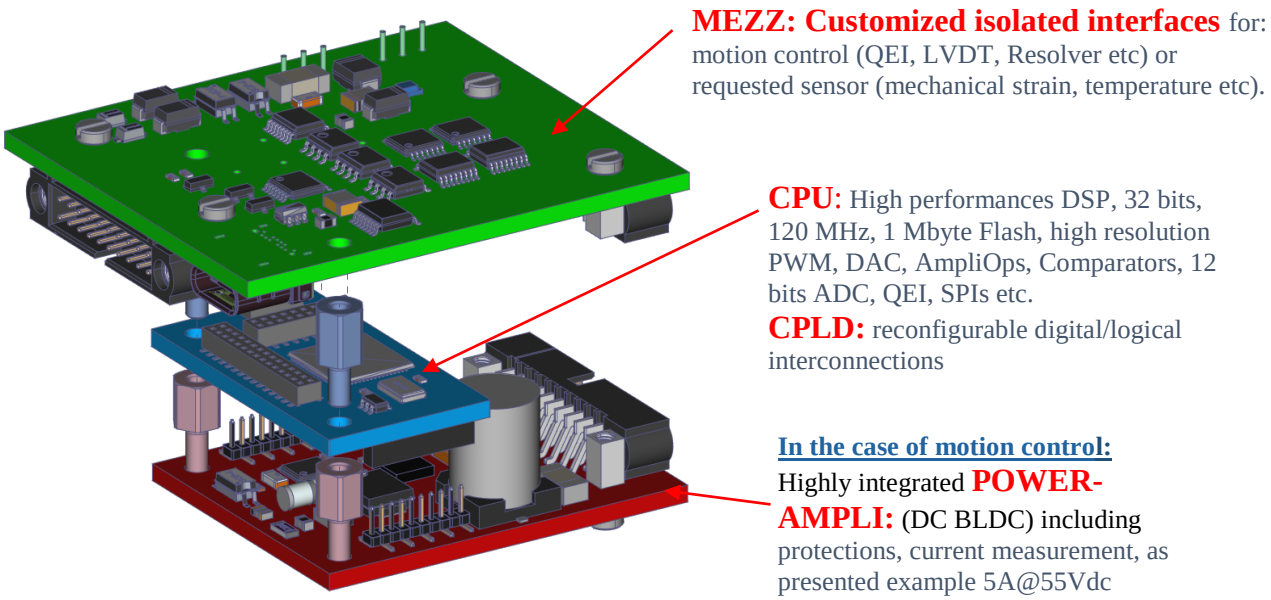
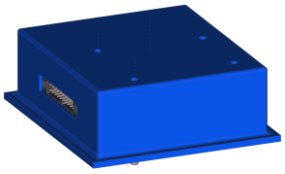


Figure 2. Proposed highly integrated configuration

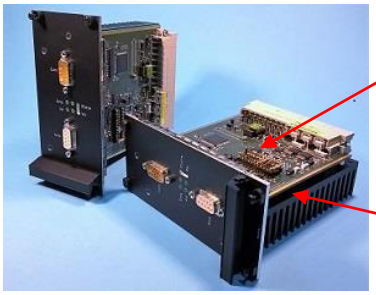
The main advantages can be presented by following list:

1. Deep modularity
2. Highly improved EMC : very short and direct connections, integrated analogue end-front, compact construction and simple global shielding
3. Large reconfiguration possibilities provided by CPLD as digital inter-connection device between DSP, interfaces and power amplifier
4. Large optimization possibilities due to high performance DSP: CPU floating 32bits, high resolution PWM and ADC
5. Low price, short customization and adaptation for requested application
6. Large mechanical implementation possibilities as standalone, 3U rack and cassettes, inside of motor etc

There are examples of two different mechanical configurations:



Stand-alone sensor or motion control configuration



3U rackable motion control configuration (two axis)

Figure 3. Mechanical implementations

3. FROM INTEGRATION TO DECENTRALIZATION

Knowing that one unit includes all functionalities necessary to control one or several sensors or one motion axis give possible to apply a distributed approach. That means to implement any unit **as close as possible** to controlled equipment.

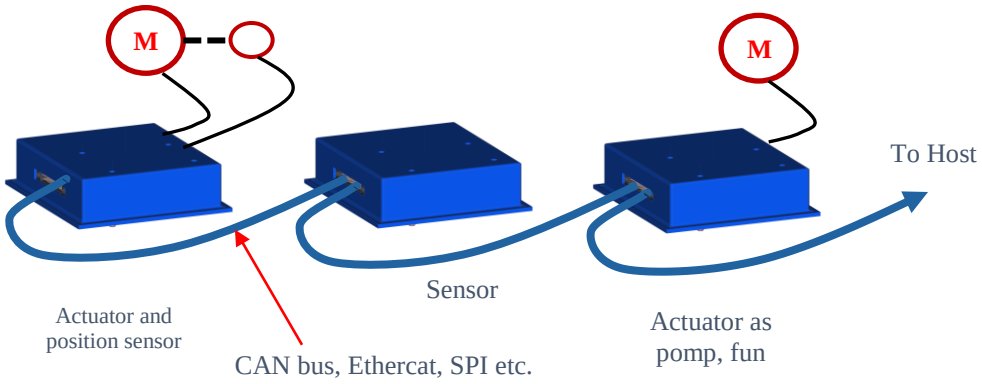
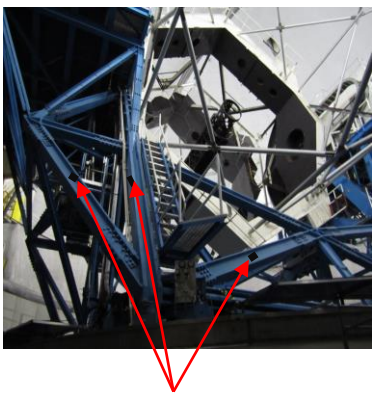
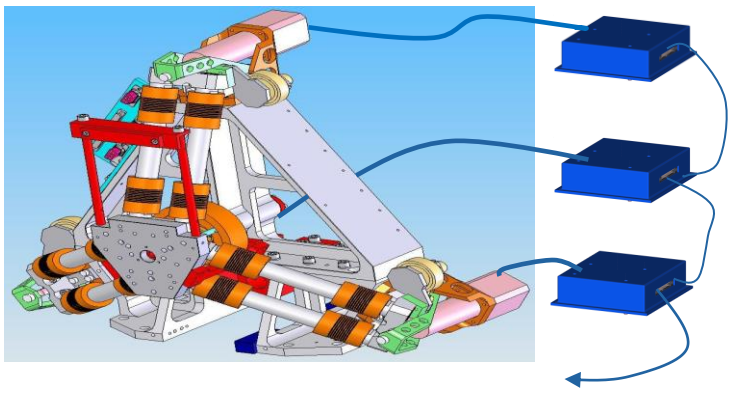


Figure 4. Distributed configuration

In this case, in function of requested dynamical performances it could be applied one of the main industrial network solution as: CAN bus, Ethercat, High speed SPI even a simple UART.



Strain sensors



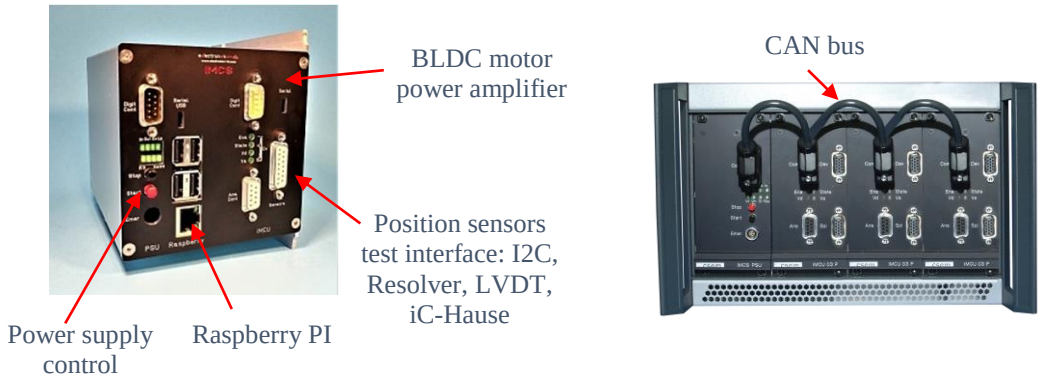


Figure 5. Different mechanical configurations

4. OPTIMIZATION

In the case of astronomical applications, especially in the case of the proposed solution, the generated power losses are a particular limiting problem. They can cause additional disorders during infrared observation.
They can be presented in two groups: material and appropriate software

Materiel:

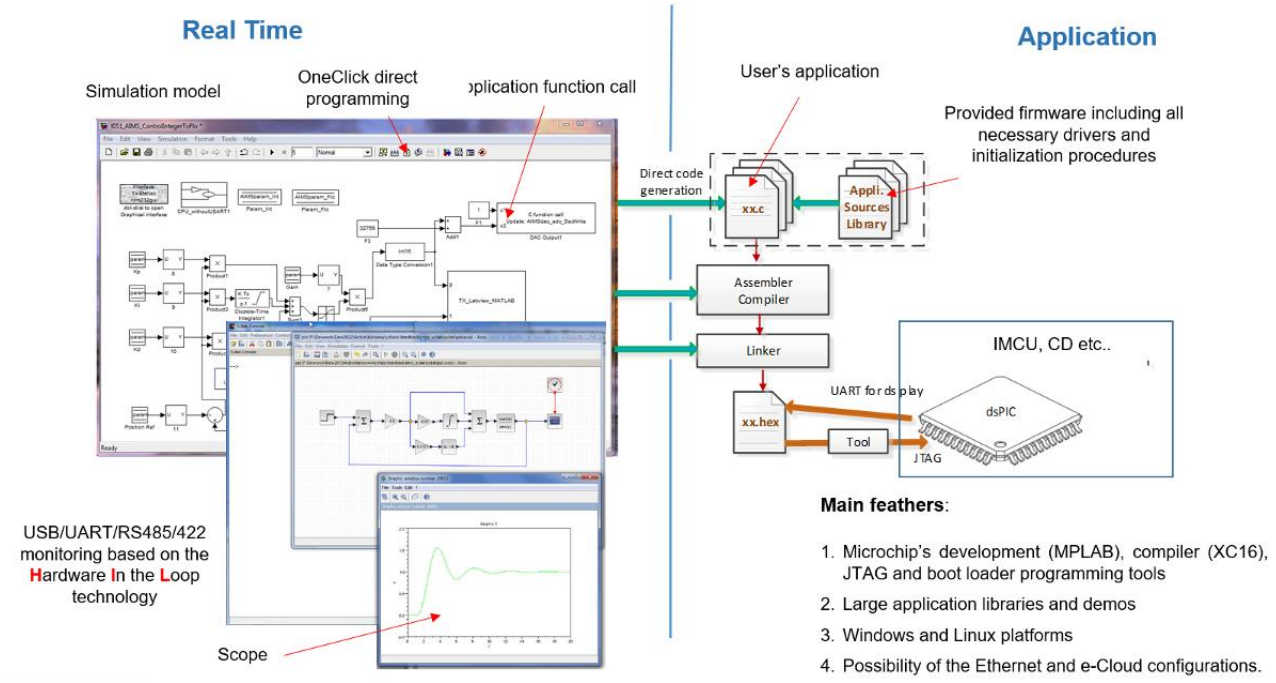
1. Improved EMC provided by:
    a. One global shield
    b. Additional LC power outputs filtering
    c. Short and very limited external inter-connections
2. High resolution PWM including additional features as compensation of 5^{th} harmonic, over current in leg limitation, death-time adjustment etc.

Such a deep optimization is possible thanks to the high integration as well as the applied high performances DSP and direct PWM and power Mosfet connections.

Software:

1. Presented unit includes also firmware with all necessary drivers and modules in C for requested application as:
    a. Initialization and initial configuration
    b. Simple (two characters and one Float or Integer parameter) command interpreter
    c. Boot-loader
    d. USB - UART basic communication
2. Additional functionalities as communication protocols, interfaces to customized sensors or high performance equipment as LVDT, Resolver etc. can be developed and implemented by user or electronics-lis's team.

Power Loses and EMC can be optimized also by a large analyze applied control algorithms. Implemented DSP is provided by Microchip and additionally it can be programmed directly from Simulink/Matlab development tools.



5. FINAL CONCLUSIONS

The presented solution is a cost and time effective solution to implement complex and high performance motion control/test systems or prototypes. It constitutes a family of ready –to-use hardware and firmware components which use a modular and distributed intelligence approaches. A bespoke solution can be quickly and easily assembled from these components, corresponding to a particular combination of actuators and sensors

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