

# JUST WHAT THE DOCTOR ORDERED: MOTION CONTROL CONFIGURATION

By Chuck Lewin, Founder & VP of Engineering, Performance Motion Devices Inc.

Motion control technology has advanced significantly in the last several years with the advent of faster, cheaper microprocessors, and the availability of ultra-efficient MOSFET-based amplifiers. Some motion-related costs have not decreased however, particularly connectors and cabling.

And in relation to medical equipment design, the need for high reliability and easy servicing is more acute than ever.

How can a motion control system be built to address these trends? We will examine that question by looking at several motion design approaches, with a particular eye toward the needs of the medical equipment market.

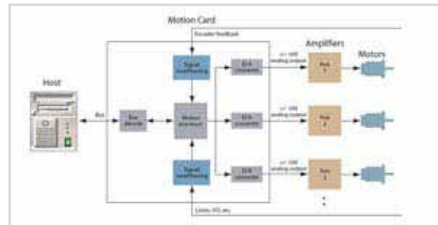


Figure 1

## WE HAVE A MOTION CARD

A very popular approach toward motion controllers is the multi-axis motion card, shown in figure 1. In this architecture, the motion card connects to external amplifiers that accept  $\pm 10V$  analog signal input, and control torque or velocity. Motion cards are available in a variety of formats including PCI, PC/104, compact PCI and Ethernet.

The multi-axis motion card approach has a number of advantages, primarily flexibility. Since the interface format to the amplifier is standardized, motors and amplifiers can easily be changed as the application evolves. Another important advantage is that synchronization among axes is relatively easy. Control is usually all under one DSP or microprocessor 'roof,' so axes servo at the same frequency, and profile changes can be synched to a single event.

A disadvantage of this architecture is wiring complexity and cost. Servo motors can have as many as 25 wires per axis to carry signals such as encoder feedback, Hall sensors, etc.

## INTERCONNECTED

For medical systems, all these connections can be a concern. Lots of connectors means lots of failure points, and more places for EMI or mechanical problems to occur.

A common approach to managing all these wires is use of a separate interconnect system. Interconnect systems include jack-screw type terminators, often on a DIN-rail mount.

This approach has the advantage of easy hand wiring and signal access.

Another popular approach is to construct a custom interconnect card.

A custom interconnect card typically uses a ribbon cable to connect to the motion card, but then breaks these signals into more manageable pieces, usually one for each motor. Often the interconnect card is designed to mount directly on top of the off-the-shelf motion card to save space and minimize connector runs.

The main disadvantage of the custom interconnect card is the upfront engineering cost. Another disadvantage is that external amplifier modules may still be needed, adding to the number of connectors. However, a solution to this problem that is becoming popular is the use of solderable motion amplifiers.

Because solder connections are more reliable and less expensive than cables and connectors, this can be a preferred approach for many motion designs.

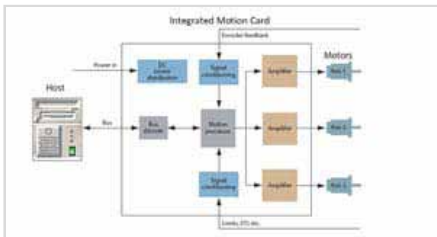


Figure 2

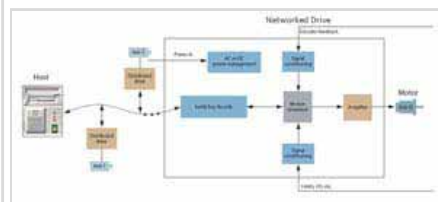


Figure 3

## NOW YOU'RE INTEGRATING !

An approach that has gained wide popularity for medical and laboratory machines in the last 10 years - shown in figure 2 - is a motion controller configuration referred to as an integrated motion card. This approach calls for the machine designer to develop a custom card that has the motion controller, the amplifiers, and the motor and hardware connection cables all designed onto a single card.

Custom-building these cards is actually not as difficult as it sounds, because the most complicated part, the motion controller, can be purchased off-the-shelf in the form of a motion processor. Motion processors are IC-based devices that provide built-in functions such as trajectory generation, servo loop closure, commutation, etc.

Alternatively, it is possible to purchase DSPs or microprocessors and design this software from scratch, but this will add to the upfront engineering effort.

When it comes to integrating amplifiers on the card, you will have two choices; off-the-shelf dedicated amplifier modules, or single-IC amplifiers. Off-the-shelf amplifier modules will cost more, but they provide high performance features like current loop, and are able to drive higher power levels. Single-IC amplifiers are less expensive, but drive less power, and do not provide some high-performance features.

The integrated motion card has several advantages. The first is per-unit cost. Compared to card-based approaches, several connectors and cables are eliminated. Another advantage is servicing simplicity. If there is a problem with the controller, there is no need to determine whether the problem is in the motion card, the amplifiers, or the connections in between. The third advantage, and perhaps the most important one for medical designers, is reliability.

The disadvantage of this approach is that the upfront engineering effort is greater than for the more modular approaches. Because of this, the approach is used when the volume justifies it, or when there are special sizes or power constraints that cannot be handled by off-the-shelf cards.

## STAND-ALONE DRIVES

One final approach to building machine controllers worth mentioning is the standalone drive, also called the networked or intelligent drive. (The phrase 'intelligent drive' is used to describe a large range of products, so be careful!) In this architecture the motion controller is a module that connects via a network to a host controller. Typical networks that are used for this purpose include RS485 serial, CANbus, Ethernet. There are also specialized networks for synchronized motion including SERCOS, CANopen, and EtherCAT.

Figure 3 shows the configuration of this architectural approach. Like the integrated motion card, stand-alone drives have the advantage of simplified wiring, since the connections between the motion controller function and the amplifier function are internal to the drive. Another advantage is that these drives can be located close to the motor or actuator.

The disadvantage of these devices, at least historically, is that their programming tends to be a bit clunky. They are typically designed to be controlled by a PLC, or internally using a vendor-specific downloadable language.

## YES WE CAN - CHOOSE AN APPROACH

When should one approach be used over another? There is no simple answer, and sometimes two architectures can successfully be used for a given application.

In broad terms, the more cost-sensitive the application, the more likely it is that you will design an integrated motion card.

When you are designing your own card, you can choose the connectors you want and their locations, the dimensions of the card, and other details to suit your particular application.

Some designers also like the fact that by designing the card, they have control over part sourcing for it.

The related approach of using a standard motion card with a custom-designed interconnect card may be a good middle ground, giving a shorter design time by using a standard motion card, while still allowing custom connectors to be installed.

Fully modular motion cards with cable-connected amplifiers or networks of stand-alone drives provide the most flexible approach and the least engineering design effort, but may be higher in cost and may require more connectors, with an attendant impact on reliability.

Knowing your own capabilities for up front design is required to determine these build versus buy choices. It is tempting to go extreme on per unit cost by buying a DSP or microcontroller and building everything from scratch, but you may be better off with a motion card, or at least an off-the-shelf motion processor.

Choosing the right approach to designing a medical or laboratory machine controller hinges on your goals for reliability, upfront engineering effort, per unit cost, and ease of serviceability. Other factors that will impact the final decision include whether the axes are tightly synchronized, the total number of axes in the application, the size of the machine, and whether more than one motor type will be used.

Performance Motion Devices Inc.  
Lincoln, MA  
[pmdcorp.com](http://pmdcorp.com)

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