Interconnect Considerations in Demanding Medical Equipment

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The medical industry's continued technological progress with electronics integration requires consideration of a broad range of new connector parameters. Between smaller, more portable diagnostic equipment with advanced functionality, and ever-evolving complex machines like MRI, CAT, and other diagnostic and monitoring applications, choosing an effective connector solution takes time and careful selection of new parameters. Moving beyond contact resistance, current rating, and working voltage, following are several new ones to add to the old list.

EMC or ESD Protection
The use of "filters" is one of several methods to achieving electromagnetic compatibility (EMC). Because EMC is a two-way street, manufacturers not only have to ensure that their equipment operates as intended, even in "electrically busy" environments; but they also cannot interfere with other surrounding electronics. With the proliferation of electronic equipment in medical areas, this EMC requirement has become more difficult to achieve.

One "tool" that offers both emission and susceptibility control, while maintaining signal integrity, is the use of filter connectors. Since they are typically used on the input/output (I/O) connections, filtered D-sub connectors are the most common and affordable filter connector category, and are ideal for many medical I/O ports. In addition to D-subs being a defacto interface on so many equipment types, the use of machined contacts with gold plated interfaces and all-metal bodies offers high reliability connections, with the added benefit of EMI filtering.

The most common "filter" component is the capacitor. Capacitors are frequency dependent; thus, when configured as a "shunt to ground," they can attenuate high frequencies (which are typically the EMI), while keeping the lower frequency signals—hence the expression "low pass filter." Most filter connectors, therefore, include capacitors—typically one at each contact position. Attenuations can range from 5 or 10 dB to as high as 80 dB, depending on the type of filter, the frequency, and the capacitance value. The most popular ones typically have a capacitance in the range of 1,000 to 2,000 pF, with an attenuation of 30 to 50 dB. Suppliers of filter connectors present the filter performance on a graph (Insertion Loss Curve) showing attenuation vs. frequency.

There are several ways to build a filtered D-sub. Each has its own advantages/disadvantages and substantial differences in frequency performance and cost variables. The designer should study the manufacturer's “insertion loss” data, and consult with technical support staff to ensure the best selection for the application. Some filter connectors use only inductive components, like ferrites, and others employ more elegant designs that use multiple capacitors plus ferrites. Filter connectors are generally 100% factory tested, thus maximizing the EMI integrity of the user's system.

Filter connectors save space (a highly desirable feature in most medical devices), because they are typically the same size as a comparable unfiltered version. They offer better shielding due to the nature of their construction and materials used. They offer better EMI control than similar looking “on the board” components. They offer higher reliability connections, because they typically start with a higher quality base connector design.

Remember that filter connectors are just one of several tools that EMC engineers use to optimize their products. Other factors related to the connector choice, such as shielding of the interconnecting cables and backshells, must also be considered.

ESD protection can also be added to the connector instead of embedding capacitors or ferrites; chip style MOVs can be placed inside the connector. Some medical diagnostic tools are designed to sense extremely small currents/voltages, so a static “zap” could be damaging to the equipment. Thus, designers may choose to add ESD protection to the I/O port of their device.

Magnetic Properties
In MRI applications, there are numerous connectors that are close to the high power magnets and sensors used for imaging. Since the presence of magnetic materials can affect the accuracy of the imaging, designers must be careful to assess areas that could benefit from the use of non-magnetic, or low-magnetic components, including the connectors. Typical I/O connectors contain steel parts, especially the stamped housings (e.g., D-subs) and mounting hardware. The use of non-magnetic parts (made from brass or zinc, for example) substantially reduces image distortions. Of course, non-metallic housings could be used too, but that often compromises EMC. As with most engineering decisions, there are always tradeoffs.

Sealing
Depending on where the medical electronic device is used, sealing against intrusion of liquids can be a consideration. Most connectors do not prevent the ingress of liquids into the device enclosure. If the device will be used in areas that could get sprayed or require intensive cleaning then it requires sealing, and an ingress protected (IP rated) connector should be specified.


The electrical/electronics industry has broad protection ratings, but most medical electronics in “likely to get wet” areas require at least an IP67 rating. This rating ensures that occasional liquid splash or spray from a hose, or even short term shallow immersion, will not allow liquids to penetrate through an exposed connector and into the device.

The popular D-sub connector is now available from several suppliers in versions sealed to IP66, 67, or even 68 ratings. Sealing can involve simple potting of the exterior, or the more rigorous internal pottings and use of elastomer seals at the interfaces, or even special molded glass seals. Again, the engineer will have a broad range of product choices, and the ever present cost vs. performance decision.

As the primary I/O connector, D-subs are typically used for connecting multiple signals (as many as 78), and in the case of combination D-subs, additional arrangements including power (to 40 amps) and RF signals (to 2 GHz).

Other I/O form factors that might require sealing can include Ethernet ports (RJ45s), and of course USB ports (in standard, mini, and micro formats). There is also a vast array of circular connectors—some in industry standard interfaces, many that are supplier proprietary. Manufacturers who require multiple sources should exercise caution in specifying circular connectors. Most of these connectors are available in IP rated configurations. The choice of a circular connector might also lead to the next consideration—latching.

Latching Systems

Most are familiar with D-subs and cables connected with hoods having jackscrews to keep them from unmating. But for devices that require frequent disconnects, alternatives should be considered. In the world of D-subs, there are slide locks and spring latches. Both lend themselves to rapid disconnect and reconnect, even with one hand, in confined spaces. This is an important connector parameter to consider, especially upon examining the bigger picture of how the device is being used in applications.

Most USBs are friction fit, meaning there is no latch, which can be a problem; but RJ45s have a snap latch. If either of these connectors is configured for IP67, then there are systems using threaded housings and 1/4 turn bayonet latches. Both prevent accidental disconnect, while still offering a fast, tool-free disconnect when required.

Small circular connectors are also prominent in medical electronics, especially for I/O ports. In addition to the threaded couplings of M8- and M12-type connectors, there are also many proprietary circulars that use a push-pull system—push to snap it on and a pull of the housing to disengage it, which still offers retention if just the cable is pulled. Price, performance, and size all become intertwined parameters.

Medical Devices Isolation Requirements

Since accessory devices or sensors/probes are likely to come into direct contact with a patient, there are rules and specifications (IEC 60601-1) for isolation against currents that could pass through the patient. This subject is complex, due to the variation of body exposure, applied voltages, resulting currents, and the hazard inherent in the device. Detailed discussion of this specification is beyond the scope of this article; however, in the quest to meet isolation needs, the selection of connectors is likely to involve decisions on conductive vs. insulated housings, creepage and clearances of contacts within the connector, and dielectric withstand specifications that may be far higher than expected, based on the specific circuitry and application.

RoHS and REACH

Materials selection used to be the intellectual property of the manufacturer. Now that regulations force the reporting needs for materials used, most top tier suppliers will be able to provide the data upon request of the manufacturer. Typically, this information is not on the website nor the product drawing, since the full material declaration, at the homogenous part level (ref. IPC1752), is quite detailed and lengthy. Since most medical electronics are shipped worldwide, this has become an important documentation stage in the component approval process.

Conclusion

Connectors in medical diagnostic equipment must meet the fundamental electrical and mechanical design needs. Defining those special needs of the medical industry and making appropriate product selection often forces the engineer to look beyond the customary electrical specifications. Advancements in medical electronics, along with safety and international regulations, have lengthened the checklist when specifying connectors. Compounding these more demanding product requirements are the ever increasing customer/user expectations for faster speeds, lighter and more compact devices, and the economic need to control costs in healthcare, making connector specification for medical electronics more challenging than ever.

Fred Kozlof has worked at CONEC [1] for 16 years and currently serves as general manager, while still remaining involved in the engineering activity. Prior to his tenure at CONEC, Kozlof designed and engineered electronic connectors, including EMI filter connectors, one of which received a US patent. He has also held upper-tier positions at Amphenol and Spectrum Control in both design engineering and product management/marketing.

http://www.mdtmag.com/articles/2012/12/interconnect-considerations-demanding-medical-equipment

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[1] http://www.conec.com