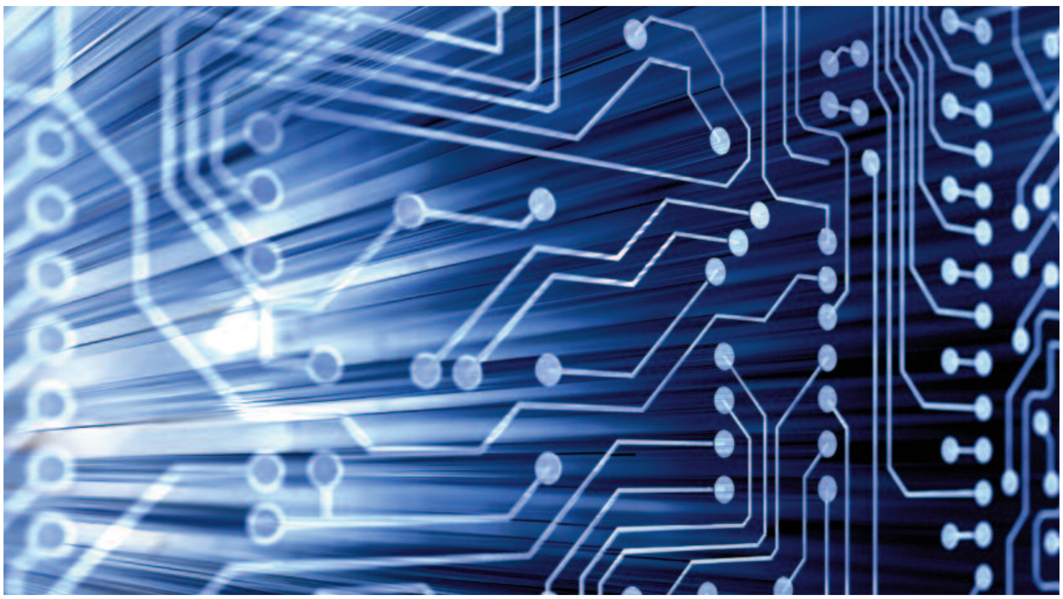
A TECHNICAL PUBLICATION OF ASSE'S
ENGINEERING PRACTICE SPECIALTY

# ByDesign

VOLUME 10 • NUMBER 1



# Designing for Product Safety Compliance

## Product safety engineering and design techniques that can improve chances of achieving product compliance.

By William Bisenius

A stage-by-stage development system that is ever mindful of regulatory requirements can provide assurance of early product certification. For many electronics manufacturing companies (EMCs), product safety compliance is an afterthought. That is, once the new electronic product has been designed for functional excellence, a compliance engineer tries to retrofit regulatory safety requirements to the design. This band-aid approach to compliance can cause dramatic increases in product development costs and significant time-to-market delays. If a company designs a product without full knowledge of the compliance requirements from the beginning, it is unlikely that the product will comply on the first try.

*By incorporating design-for-compliance principles at every stage of a product's development, a manufacturer can take control of the product compliance process.*

Designing for compliance is a process that incorporates product safety design principles at all stages

*continued on page* ***24***



**For a complete Table of Contents, see page 3**

## Designing for Product Safety Compliance

*continued from page **1***

of product development, from product concept through the design process, into production and continuing as engineering change orders come in the future. It involves all departments related to the development and release of a new product, including corporate management, marketing and sales, engineering, purchasing, production and compliance. By employing this systematic approach to product safety, product developers can design products faster and at a lower cost.

For manufacturers to control development costs and delivery schedules, they should take a serious and deliberate approach to regulatory compliance. Most manufacturers now design products with EMC compliance in mind. However, many still apply product safety design principles after the fact.

Product safety design for compliance can be broken down into five engineering segments:

1) Design parameters.
2) Enclosure and overall product layout.
3) Power system and power supplies.
4) Secondary circuits and printed circuit board (PCB) layout.
5) Component selection.

This article examines product safety engineering and design techniques in these five areas that can improve chances of achieving product compliance the first time a piece of equipment is submitted for certification.

### Identifying Design Parameters

Several key marketing and engineering parameters must be identified and fully understood before design work begins. Focusing on these goals and considerations will ensure that the correct product safety compliance standards are referenced during the design process. Also, this way, all applicable requirements within these standards and only those that are applicable will be used.

Important parameters of which product developers should be aware include:

•Marketing parameters: countries to market, timeframe to market, product features, product appearance, predefined materials and predefined locations for product features.

•Engineering parameters: electrical ratings, form factor, common components versus custom components, inputs and outputs and options and accessories.

•Engineering design objectives (use of the previous parameters to identify several knowns concerning the standards and the product): environmental conditions, installation category, equipment class, pollution degree and circuits that the user may and must access (accessibility).

All of these things go into shaping the informed systems design that will be the foundation for all electrical and mechanical component development.

### Enclosure & Overall Product Layout

Product safety is defined as the process of designing a product to protect the user from six potential hazards: shock, energy, fire, injury, radiation and chemical. The product's enclosure is the most critical element of this protection. The enclosure can provide a level of protection from all types of hazards simply by preventing the user from coming into contact with a potential hazard.

This in turn will greatly affect the circuit design requirements according to the relevant safety standards. If the user is not able to touch the circuit, there will be one set of requirements. However, if the user can touch the circuit, then another, more stringent, set of requirements applies.

Key design considerations for an enclosure are material of construction, shape and size of the housing, strength (to some extent a function of the choice of material), grounding, ventilation and access panels or openings.

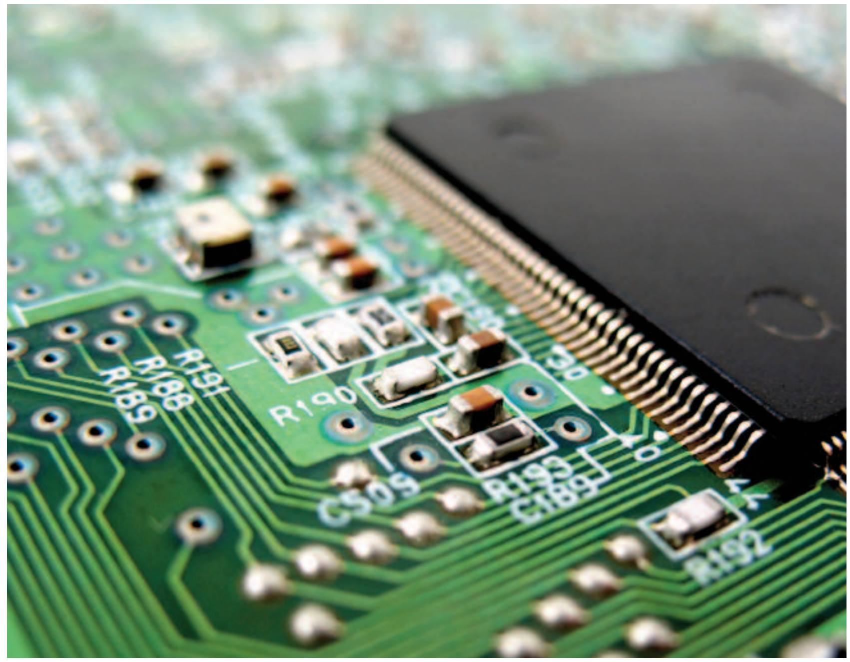
Within the enclosure, the overall product layout will have a direct effect on the selection of key components and also on the amount of flexibility the design engineer will have in choosing second sources for key components. The principal layout and circuit placement issues involve separations between mains and operator-accessible circuits, hazardous live and operator-accessible circuits and hazardous inputs and nonhazardous circuits. Mains refers to all circuitry electrically connected to the mains circuit, regardless of the operating voltage of the circuit.

A hazardous live circuit can be any secondary circuit that operates at a voltage considered a shock hazard by the applicable standard (for example, greater than 30 V rms, 42.4 V peak, 60 V dc for the 60950 family of standards). Hazardous inputs would be any of the product's inputs that are rated at a voltage considered a shock hazard by the safety standard applicable to the end product.

### Circuit Classification Map

Although a product may visually appear well laid out—the harnesses routed neatly, the wiring color coded, components mounted securely, multilayer circuit boards spaced apart and so on—its product safety circuit classification map may reveal safety compliance chaos. A circuit classification map is a block diagram of a product where each block represents all circuits that share electrical continuity. Each block is further defined by its shock-hazard level, for example, mains, extra-low voltage (ELV) or safety extra-low voltage (SELV).

A product layout designed with the objective of achieving first-time regulatory compliance and certification must have more than a nice visual appearance. It should be configured to provide maximum segregation of hazardous and nonhazardous circuits. In terms of product safety and circuit layouts, a hazardous circuit is one that involves a risk of electric shock, while a nonhazardous circuit is one that does not. A nonhazardous circuit also is isolated from any risk of shock by two levels of shock protection. The definition of this risk varies by standard.




*A circuit board that may appear to be well laid out could nevertheless be flawed by a failure to incorporate the appropriate creepage and clearance distances.*

When locations of some product features are predetermined (for example, marketing says the knob must be exactly at the center of the front panel), they may deny the designer complete freedom in achieving circuit segregation. Identification of areas where segregation cannot be designed in is central to determining where insulation must be added to the package to provide electrical (as opposed to physical) segregation.

### Power System

Once the essential aspects of a compliance-oriented enclosure and overall product layout are understood, the power system becomes the next critical area to address. Beginning with the overall power system, the product developers primarily need to determine:

•the desired product voltage and frequency rating (e.g., 120/240 V ac? 50/60 Hz? 48 V dc?);

•how may different sources of power there will be (ac? dc? battery operation?);

•the overcurrent protection rating for each power source (such as how the circuit breaker will be rated based on the current rating of the product);

•whether the product will be permanently or cord-connected; if cord-connected, what plug configurations will be used, what will be the proper plug for the current rating of the product in each country of use and what secondary-circuit power sources (5 V dc, 12 V dc, 24 V ac, or other) will be needed;

•whether there will be a need for any additional fusing within the product.

### Power Supply

The product's power supply is the next point of focus. Several key power supply considerations exist. The first is whether it should be a custom or off-the-shelf power supply. A custom power supply may not be certified and thus could entail additional time and expense for evaluation. In addition, controlling construction of the power supply once it has been evaluated could be difficult.

Another question is whether a linear or a switching power supply is appropriate. If the product is assigned a dual-voltage rating (e.g., 120/240 V ac), this could have a significant effect on voltage selection means and instructions. Today's switching power supplies typically are autoranging and do not require a voltage selection means.

If the product is to have multiple input-voltage ratings, how it is to be reconfigured for each different voltage rating is a matter to be determined. Autoranging is the best solution if the design can incorporate an autoranging power supply.

The retailer, or end user, of the product needs only to select the correct power cord. A voltage-selector switch is the next best choice, as it allows the user to reconfigure the product. If the manufacturer wants to mark the product with multiple input-voltage ratings, then a "factory-wired for" marking is called for. This legend is typically used when the product requires internal changes to be able to accommodate different input voltages.

Perhaps the power supply is already product safety-certified for the intended application. If not, the manufacturer will need to have it evaluated by the safety agency along with its product. Medical product manufacturers should take care that certified transformers and power supplies are in fact certified to meet applicable medical standards, such as UL 60601-1 and EN 60601-1. Test equipment manufacturers are permitted to use power supplies certified to either the 60950 or the 61010 standards families.

Care should always be taken in selecting linear transformers that are certified because many are certified for construction only or for general-purpose use. Although such components will work, the manufacturer will need to incur additional expense (and spend time) having its certification laboratory reevaluate the transformer to the applicable end-product standard.

A final noteworthy consideration in this area regards how the linear transformer or power supply outputs are classified, i.e., as SELV, ELV or hazardous. Product developers should always get the conditions of acceptability from the certification report for the power supply or transformer. Just about anything can be waived off on the component power supply evaluation with a condition of acceptability that the problem be addressed in the end product.

Developers should also insist on SELV-certified outputs for all certified power supplies unless the application specifically requires otherwise. SELV outputs are by definition user-accessible and can greatly limit the evaluation of the product.

### Secondary Circuits & PCB Layout

The power supply output classifications (SELV, ELV, hazardous) serve as the starting point for the secondary circuit design. The same circuit separations are essential for secondary circuits as were key to the overall product layout. These areas are critical, as they require at least minimum spacings between traces and between components. They also have additional insulation system requirements (that is, within transformers and optoisolators).

If the designer keeps these separation areas within the product to a minimum, the amount of area in which there is design flexibility will be greatly increased. The areas on each circuit board that require circuit separation are the same as with the overall product: between mains and operator-accessible circuits, between hazardous live and operator-accessible circuits and between hazardous inputs and nonhazardous circuits.

A circuit board that may appear to be well laid out could nevertheless be flawed by a failure to incorporate the appropriate creepage and clearance distances. Creepage distance is the shortest distance over the surface between two conductive parts, and clearance distance is the shortest distance through air between two conductive parts. If these distances are inadequate, the board may need to be relaid.

Consequently, to better the chances of achieving compliance with the first design, a circuit classification map should be prepared for every circuit board that contains both hazardous and nonhazardous circuits. The map can be used to identify places in the board layout where circuit separation—that is, greater creepage clearance and distance—should be incorporated.

## Component Selection

One important outcome of having taken the previous steps is that the designer thereby identifies the components that are critical for safety compliance: the enclosure, the power supply and other components in the power-source path and the components that provide isolation or separation between hazardous and nonhazardous circuits. These critical components constitute a basis for determining product compliance.

Toward this purpose, the design engineer should identify several significant details pertaining to each critical component, specifically, whether it:

- involves hazardous voltage levels at its input, its output or internally;
- incorporates insulation for shock-hazard protection;
- incorporates flammable materials;
- is to have alternative sources of supply besides the preferred supplier;
- is certified and if so, to what requirements and for which markets.

These details will enable each component to be evaluated with respect to the applicable requirements in the safety standard.

All components found not to be critical to compliance should not be controlled in the safety compliance report. As such, these other components may be changed without affecting the product's safety compliance.

Remember that even if a component is safety-certified, it may not have been evaluated for the application at hand. Certification marks on a component can be helpful as an early step toward determining their acceptability for the application, but still, the conditions of acceptability for each certified component need to be examined. The conditions of acceptability will identify the level to which the component has previously been evaluated and, more importantly, which aspects have not been evaluated.

Manufacturers should not let a certification lab blueprint its product in the compliance report. The company should provide at least its own list of critical components to the certification lab at the time of product submission. For manufacturers that have the time and the ability, it is further recommended that they draft their own compliance report and provide it to the lab along with the equipment.

## Conclusion

By incorporating design-for-compliance principles at every stage of a product's development, a manufacturer can take control of the product compliance process and, if not ensure first-time regulatory compliance and certification, at least improve the likelihood of such success dramatically. Not only will this reduce the engineering redesign required for each development project, but it will accelerate time to market as well. Getting new and enhanced products to market smoothly and quickly should substantially improve the company's competitive performance. ✪

**William Bisenius, NCE,** *is president and cofounder of Educated Design & Development Inc. in Morrisville, NC. He has worked in the product safety field for more than 20 years, including previous experience as an engineering group leader and information technology equipment seminar leader for Underwriters Laboratories. He develops product safety equipment and teaches manufacturers how to design products for immediate safety compliance. He may be contacted at billb@productsafet.com.*