‘Re³-inforced’ Converters for Maximized Patient Protection

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Since medical electrical equipment must conform to a high safety standard, DC/DC converters are often used to provide the required electrical isolation. Reinforced isolation offers an additional level of safety beyond the standard, but up until recently, it was extremely difficult to find compact DC/DC converters with the large air and creepage distances required to meet the definition for reinforced isolation.

Generally, the patient environment is defined as the area in which the patient may access medical equipment or where he may be connected to medical equipment in the course of an examination. To avoid electrical shock, the medical safety standard demands galvanic isolation between the supply, the equipment casing, and the diagnostic tools. Two safety barriers are paramount the primary barrier within the power supply of the equipment and a secondary barrier that isolates sensors and electrodes that may be in direct contact with the patient. If the primary isolation fails for any reason, the secondary isolation will still protect the patient.

Figure 1 shows the isolation features of a mains powered diagnostic unit intended for direct patient contact in this case, an ECG unit. For the secondary isolation of the body electrodes, DC/DC converters are used which feature reinforced isolation for additional safety.

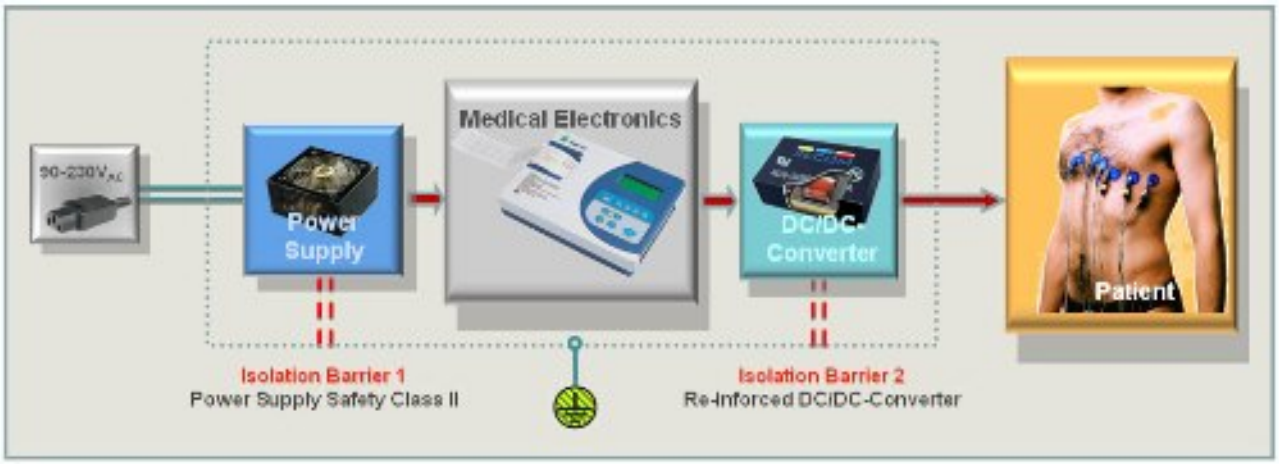

Figure 1: Mains powered medical equipment requires two isolation barriers. The first is within the AC/DC power supply. The second is provided by the isolation of the DC/DC converters. RECOM has developed five reinforced isolation DC/DC product families with power ratings from 1.0 W up to 6.0 W in compact industry-standard case sizes.

Reinforced Isolation
The isolation of DC/DC converters approved for medical applications depends not only on the level of the isolation voltage, but more so on the quality of isolation.

For industrial applications, a functional isolation usually suffices, whereby the primary and secondary windings can be overlapped and the windings are insulated just by the coating on the wires. This method of construction gives high conversion efficiency because of the close proximity of the windings to each other. Also, although the insulating wire enamel is very thin, it can withstand up to 4.0 kVDC as long as it is not damaged. However, damage during the manufacturing process or excessive stresses in the windings can reduce the dielectric strength over time and can eventually cause isolation failure in the equipment.

UL [1] (Underwriter Laboratories Inc.) has thus defined different “qualities” of isolation: basic, supplementary, and reinforced (Table 1). The isolation class not only demands additional physical insulating barriers between input and output in case the functional isolation fails but also provides minimum creepage and clearance distances depending on the working voltage. For a basic isolation DC/DC-converter with an input voltage of up to 75 V, a clearance of 0.7 mm is mandatory. For a similar converter with reinforced isolation, the clearance must be 2.4 mm (i.e., three times larger). The same applies for the creepage distance, which needs to be 4.6 mm for a reinforced converter instead of only 1.3 mm for a basic isolated one.

Isolation Class	Input Voltage	15 VDC	36 VDC	75 VDC	150 VDC	300 VDC
		12 VAC	30 VAC	60 VAC	125 VAC	250 VAC
Basic	Clearance	0.4mm	0.5mm	0.7mm	1.0mm	1.6mm
	Creepage	0.8mm	1.0mm	1.3mm	2.0mm	3.0mm
Supplementary	Clearance	0.8mm	1.0mm	1.2mm	1.6mm	2.5mm
	Creepage	1.7mm	2.0mm	2.3mm	3.0mm	4.0mm
Reinforced	Clearance	1.6mm	2.0mm	2.4mm	3.2mm	5.0mm
	Creepage	3.4mm	4.0mm	4.6mm	6.0mm	8.0mm

Table 1: This table shows the defined air gap and creepage distances depending on the input voltage. The values for reinforced isolation are approximately three times greater than for basic isolation.

Lower Efficiency with Conventional Reinforced Technology
To meet the isolation class criteria, the primary and secondary windings can no longer be overlapping and must be physically apart. The winding scheme determines the size of the transformer and also the efficiency, since the magnetic fields are now no longer optimally overlapped with the increased separation.

An example: The efficiency of a conventionally isolated converter with overlapping primary and secondary windings is approximately 85%, while a reinforced converter in conventional design achieves only 75%.The difference in efficiency has a marked influence on the performance of the converter. The losses for a standard isolated 3 Watt converter are around 500 mW (3.0 W/0.85 – 3.0 W = 0.529 W), while they are

twice as high for a conventionally manufactured reinforced-converter with the same output power (3.0 W/0.75 – 3.0 W = 1.0 W). The higher internal heat dissipation reduces the maximum operating temperature from 85°C down to only 75°C.

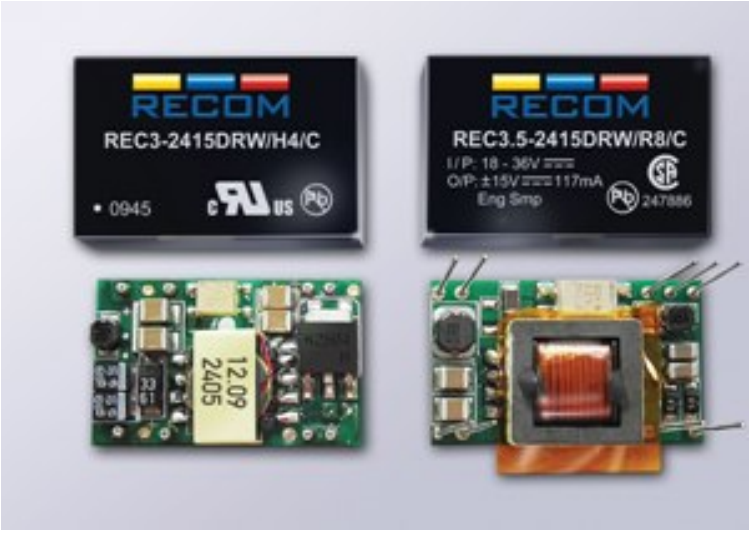

Figure 2: A comparison of the reinforced isolated REC 3.5 (right) with a standard isolated REC3 DC/DC converter. Although the reinforced transformer is larger, the overall case size and pin out remain the same.

Breakthrough Technology

Development engineers at RECOM [2] in Austria and Taiwan were able to design a transformer that meets all the conflicting requirements for wide clearance and creepage distances, multiple layers of insulation and a compact size (Figure 2). This new concept has been filed for a patent under the designation “Re³-inforced.” DC/DC converters incorporating this design achieve a higher isolation, better efficiency, and more rated power than comparable standard products. Apart from the higher isolation of up to 10 kVDC, it was also possible to reduce the winding capacitance by a factor of three down to 20 pF. This leads to extremely low leakage currents, also a common requirement for medical applications. These converters are continuously short circuit and overload protected and can optionally be supplied with under voltage lockout and a remote on/off pin. They are certified to EN60601-1, CSA C22.2 601-1, and UL60601-1.

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