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Power Supply Designed for Operation in Very High Strength Magnetic Fields

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A scalable point-of-load power supply design utilizing piezoelectric transformer coupling mechanism and air-core inductor components such that the design is immune to the effects of strong static magnetic fields, whereby the entire power supply is located within the strong magnetic field.

SPECIFICATION

The piezoelectric transformer may be driven open-loop or controlled by a closed-loop system, which adjusts the frequency and or amplitude of the excitation signal to regulate the output amplitude. Inductors required for creating the excitation (input) waveform, or used in the filtering or rectification of the output waveform utilize air-core designs to prevent saturation that would occur with conventional (iron core) inductors.

This type of power supply could be implemented in various topologies which currently use conventional transformers, including:

- DC-AC (Step-Up) Inverter
- Switch mode Isolated DC-DC converters (step up or down) of various topologies

Examples of Applications:

- Backlight Inverter for LCD Display in or near the bore of MRI machine or other environment with a very strong magnetic field
- Voltage regulation for circuitry in accessories or subsystems used in an MRI or other environments with a very strong magnetic field
- Isolated Power Supply for Medical Devices used in the MRI Environment (e.g., patient interfaces, device interconnects, serial ports, display interfaces) or other environment with very strong magnetic fields
- Isolated Power Supply for other applications in environments with very strong magnetic fields

Novel Features:

- Efficiently provides isolated or non-isolated voltage regulation to loads in an environment with a strong static magnetic field
- Power supply can be positioned at the point of load in magnetic environment -- can efficiently supply very high voltage loads without cabling losses, capacitive/inductive loading
- Can efficiently provide a high degree of electrical isolation, unlike air core transformers in which efficiency drops with increased separation (isolation)

In prior art, one of the following approaches is used for power supplies in strong magnetic fields:

- Linear Regulation which does not require transformers or inductors, and is therefore immune to magnetic fields, but is unable to provide any of the following: Isolation, step-up conversion, or DC-AC inversion
- Switching Regulators using air-core inductors, but are unable to provide the following: isolation, or high-gain DC-AC inversion
- Isolated Transformer-based regulators, using large air-core transformers, but which suffer considerable efficiency losses, especially if a high degree (greater than 500V) of isolation is required. These transformers may become unwieldy if large voltage gain is required
- Use conventional power supply designs, but locate the power supply outside of the strong magnetic field, and connect to the load with long cabling. This may introduce unwanted interference in some environments (such as MRI). The supplies must be capable of driving the additional capacitive and inductive load introduced by the cabling, and the cabling must be designed to carry the voltages required.

These features are not obvious in the following ways:

- PZT based power supplies have been traditionally applied in space constrained applications (e.g., laptop computer backlight power supplies), with traditional ferrous inductors, when needed
- This design leverages an unexploited benefit of PZT technology for power supply designs – magnetic field immunity.
- Combined with existing art in use of air-core inductors.

Uses and Problems Solved:

Examples of Applications

- Backlight Inverter for LCD Display in or near bore of MRI machine or other environment with a very strong magnetic field
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- Isolated Power Supply for Medical Devices used in the MRI Environment (e.g., patient interfaces, device interconnects, serial ports, display interfaces)

Problems Solved

- Inability to use medium or large size CCFL-backlit displays in MR procedure room; alternate backlighting techniques result in dim displays, poor contrast

- Eliminates inefficient, bulky power supplies located remotely with bulky cables
- Large air-core based isolated power supplies which drive device size and generate excessive EMI
- Provides high degree of isolation required for patient interfaces which is not practical using air-core transformers