



FAQ: Isolation, *iCoupler*® Technology, and *iCoupler* Products

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Isolation

What is isolation? Why is it needed?

Isolation is a means of preventing current from flowing between two communicating points. Typically, isolation is used in two general situations. The first is where there is the potential for current surges that may damage equipment or harm humans. The second is where interconnections involve different ground potentials and disruptive ground loops are to be avoided. In both cases, isolation is used to prevent current flow yet allow for data or power flow between the two points.

What are common applications that use isolation?

Isolation is commonly found in applications involving high voltage, high-speed/high-precision communications, or communication over large distances. Common examples of such applications include:

- Industrial I/O systems
- Sensor interfaces
- Power supply/regulation systems
- Motor control/drive systems
- Instrumentation

These applications can be found in a wide range of markets, including:

- Medical equipment
- Communication networks
- Plasma display panels
- Hybrid automotive vehicles

How is isolation specified?

The isolation characteristics of an isolator are specified in a variety of manners, including:

- Isolation rating
- Working voltage (or rated mains voltage)
- Transient immunity (common-mode rejection)

The degree to which an isolator successfully insulates one side of an isolation barrier from high voltages on the other side is commonly described by the isolator's *isolation rating* and by its maximum *working voltage* (or *rated mains voltage*). In addition, the degree to which an isolator continues to correctly transfer a signal across an isolation barrier in the presence of a common-mode transient is described by its *transient immunity* (or *common-mode rejection*). Each of these three parameters is described below.

What is *isolation rating*?

An isolator's *isolation rating* (also called the *test voltage*) is a measure of the protection provided against short-duration, common-mode voltage differences. Usually specified in terms of a 60 Hz RMS value, it is a rating of how much voltage can be safely applied between the input and output terminals of the device for a duration of one minute. A common isolation rating

found on isolation devices is $2.5\text{KV}_{\text{RMS}}$. Other devices have ratings such as $3.75\text{KV}_{\text{RMS}}$ or higher. The isolation rating does not describe how much voltage can be safely applied across the part on a long-term continuous basis – this is described by the "working voltage" or "rated mains voltage."

What are *working voltage* and *rated mains voltage*?

The *working voltage* or *rated mains voltage* defines the maximum steady-state voltage that a part can support on a long-term continuous basis. Typical values range from 100 to 600V_{RMS} .

What is the relationship between *working voltage* and *isolation rating*?

The relationship between a given working voltage and the required test voltage is complex and is a function of the application, the magnitude of common-mode voltage transients (*Installation Category*), the "cleanliness" of the environment (*Pollution Degree*), and the required insulation type (*Insulation Level*). As a representative example based on IEC 1010-1 (international standard for measurement and control equipment), a measurement and control application involving installation category II, a pollution degree of 2, basic insulation, and a working voltage of 300V_{RMS} has a required test voltage of $1.35\text{KV}_{\text{RMS}}$. This means that for an isolation component to be suitable for this application, it must support steady-state common-mode voltages differences of at least 300V_{RMS} and transient common-mode voltages differences of at least $1.35\text{KV}_{\text{RMS}}$. The relationship between working voltage and isolation rating is defined by the specific safety standard for the end-equipment under consideration.

What is the difference between *basic* and *double (or reinforced)* insulation levels?

In general, protection against electric shock may be provided by adequate clearance (a physical spacing from the live part) or by one of two insulation levels. These insulation levels are *basic insulation* and *double (or reinforced)* insulation. The required insulation level is determined by the voltage levels involved as well as the presence or absence of a connection from accessible parts to earth ground. In general, compared to an isolator providing *basic* insulation, an isolator providing *double or reinforced* insulation has greater requirements on its test voltage as well as on its input-to-output spacing. The required insulation level is defined by the specific safety standard for the end-equipment under consideration.

What are *transient immunity* and *common-mode rejection*?

An isolator's *transient immunity* specifies how fast of a common-mode transient between input and output a part can be subjected to while maintaining correct signal transmission. Many isolators have no specification on this parameter while others have values ranging from 5 to $25\text{KV}/\mu\text{s}$. All iCoupler products have a transient immunity specification of at least $25\text{KV}/\mu\text{s}$.

What other parameters are important when considering an isolation device?

The ideal isolator consumes no power, imposes no signal errors, and supports any type of input signal. As a result, the important performance metrics are as follows:

- Required supply current, input signal current, or input drive current
- Propagation delay through the part
- Pulse width distortion: the degree to which the output pulse width of a signal varies from the input pulse width
- Data rate: the maximum signal data rate that the part can support
- Supply and signal voltage range: the range of voltages that the part can support
- Operating temperature: the range of temperatures that the part can support

Which of the above metrics are important to a particular user is a function of the application in question. Often in a specific application, certain parameters are important and others are not.

Other performance characteristics important to users are an isolator's power-up/down characteristics, its performance in the presence of input noise, and its performance in the presence of a DC input or after a loss of power. In all cases, the output of an isolator should properly reflect the correct input state.

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Regulatory Standards

What regulatory standards address isolation products?

There are a wide variety of safety standards related to isolation at both the system and component levels, for various geographic regions, and for various applications. Shown below is a table summarizing commonly-used standards for the U.S., Europe, and International geographic regions.

Table 1. Application-Level Standards.

Application	U.S.	Europe	International
Industrial	UL 508	EN 50178	IEC 604
Information Technology	UL 1950	EN 60950	IEC 950
Medical	UL 2601-1	EN 60601	IEC 601
Measurement and Control	UL 3111	EN 61010-1	IEC 1010-1
Telecom	UL 1459	EN 60950	IEC 950
Household	UL 8730-1	EN 60065	IEC 65

Table 2. Component-Level Standards.

Component	U.S.	Canada	Germany/Europe	International
Isolator	UL 1577	Component Acceptance Notice #5	DIN EN60747-5-2 DIN V VDE V 0884-10	IEC 747-5

The standards that apply directly to isolation components are those of Table 2. The standards of Table 1 apply to applications that use isolation components. The designer of such an application must assure that the appropriate isolation component is selected such that compliance with the relevant application-level standard is ensured. However, the application-level standard is not directly applicable to the isolation component. Only the standards of Table 2 are imposed directly at the component level.

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Traditional Isolation Techniques

What types of technologies have been used to provide isolation?

There are three common isolation technologies:

- Optical
- Transformer
- Capacitive

Each has benefits and disadvantages related to price, performance, reliability, size, features and functionality. Historically, optocoupler and transformer technologies have been the most commonly used methods.

What are optocouplers? What is optical isolation?

Optocouplers are a form of optical isolation that employs light to transmit information across an isolation barrier. Typically, a light emitting diode (LED) transmits information to a light sensitive receiver (e.g., a transistor). Optical isolation's primary benefit is that it is widely used and accepted as a low-cost isolation solution for transmission of slower digital signals; high-speed, digital optocouplers tend to be expensive. Optocoupler-based methods are commonly used in applications in which the DC state of a signal is important. Because LEDs may wear out over time, optical isolation typically requires compensation and guardbanding to guarantee application operability over life.

What is transformer isolation?

Transformer isolation employs transformer coils to transmit information across an isolation barrier. Changes in current through the transformer winding on one side of the isolation barrier induce a corresponding current on the transformer winding on the other side of the isolation barrier. Transformer-based methods have been commonly used in applications involving AC signals (Ethernet, for example) that are well suited for transformer coupling. Transformer isolation has advantages in systems with high data rates, and it can also be used to provide an isolated power supply; however, transformers have typically been bulkier than alternative solutions.

*i*Coupler technology (see below) is a form of transformer isolation that employs micro-transformer coils to address the size and integration disadvantages of discrete transformer solutions.

What is capacitive isolation?

Capacitive isolation employs capacitors to couple data signals across an isolation barrier. This approach can offer significant performance advantages relative to optocoupler but typically suffer a high vulnerability to common-mode and ESD transients.

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*i*Coupler Technology

What is *i*Coupler technology?

*i*Coupler technology is a transformer-based approach to isolation that combines the advantages of optocoupler, transformer, and semiconductor technologies. By integrating micro-transformers onto semiconductor dice, isolation is provided without the detrimental characteristics of the electro-optical conversions present in optocouplers. These include excessive power consumption, large timing errors, and constraining data rate limitations. Safety agency-recognized insulation is achieved through the use of a special insulation layer between the transformer coils. The common transformer problem of achieving DC-correctness is avoided by the use of patented "refresh" circuitry that updates the output with the correct input state in the absence of input signal transitions.

What are the benefits of *i*Coupler technology?

*i*Coupler technology provides benefits in five key areas:

- Integration (size/cost)
- Performance
- Power consumption
- Ease-of-use
- Reliability

Integration benefits are provided by the ability to readily combine *i*Coupler channels with other semiconductor functions or to combine multiple *i*Coupler channels in a common package thereby reducing size and cost relative to optocoupler implementations. Performance benefits are provided in the form of increased timing accuracy, transient immunity, and data rates relative to optocoupler components. Power consumption benefits are provided in the form of 10-to-50 times lower power consumption as well as the accompanying reduction in thermal dissipation.

Ease-of-use benefits are provided by the elimination of many of the difficulties presented by optocoupler technology as well as the addition of new features that facilitate the use of *i*Coupler isolators in new designs. Optocoupler problem areas that *i*Couplers eliminate include their characteristic of widely-varying current transfer ratios, their LED wear-out phenomenon and the design burdens this imposes, and their need (in most optocouplers) to drive their input with high current to turn on the LED. Additional ease-of-use features that *i*Couplers provide include the ability to operate at reduced supply voltages, the ability to translate an input signal of one voltage into an output signal of a different voltage, the use of voltage-based digital interfaces, and the ability to operate over a wide temperature range.

Lastly, reliability benefits are achieved by the elimination of the LEDs contained within optocouplers. By using only standard CMOS process technology, *i*Coupler devices provide the same lifetime characteristics as other standard CMOS products.

How much isolation can *i*Coupler products provide?

As of this writing, most *i*Coupler products carry an isolation rating of either 2.5KV_{RMS} or 5.0KV_{RMS} (the ADuM240x and ADuM225x isolators carry an isolation rating of 5.0KV_{RMS}). The maximum working voltage that *i*Coupler products support is a function of both the safety approvals a given product has as well as its insulation lifetime as evaluated by testing performed by Analog Devices in addition to that of the safety agencies.

All *i*Coupler products support working voltages up to 400 V_{RMS}. The ADuM240x and ADuM225x families support higher working voltages.

The maximum working voltage supported by the ADuM240x or ADuM225x depends on the nature of the common-mode

waveform that is imposed across the isolation barrier. This is due to the fact that the *iCoupler* insulation system is stressed differently for the various waveforms shown below. In the case of bipolar AC waveforms, the maximum working voltage is set by the criteria that the insulation have a 50 year minimum lifetime. In the case of other types of voltage waveforms, the maximum working voltage is limited by regulatory safety approvals – despite the insulation’s ability to withstand higher voltages with a 50 year minimum lifetime. The table below summarizes the maximum recommended voltages for the ADuM240x and ADuM225x as a function of waveform type:

Table 3: ADuM240x and ADuM225x Maximum Working Voltages

Parameter	Max	Constraint
AC Voltage, Bipolar Waveform	400 V _{RMS} (565 V _{PK})	50-year minimum lifetime
AC Voltage, Unipolar Waveform	519 V _{RMS} (848 V _{PK})	Maximum CSA/VDE approved working voltage
DC Voltage	848 V _{PK}	Maximum CSA/VDE approved working voltage

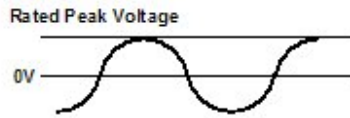


Figure 1: Bipolar AC Waveform

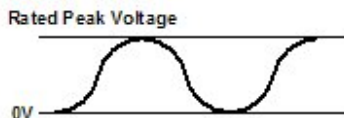


Figure 2: Unipolar AC Waveform

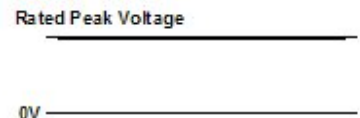


Figure 3: DC Waveform

With which regulatory standards do *iCoupler* products comply?

iCoupler products typically carry at least a 2.5 kV_{RMS} UL rating and a 400 VRMS working voltage approval from CSA and UL. The approvals and details for each specific product are summarized in the table available at www.analog.com/iCouplerSafety.

Do *iCoupler* products have VDE certification for reinforced insulation?

Yes. *iCoupler* products have now been approved for reinforced insulation by VDE. Until recently, no VDE standard covered reinforced insulation for magnetic couplers such as the *iCoupler* family of digital isolators; however, VDE released DIN V VDE V 0884-10 (VDE V 0884-10) in December 2006, and *iCoupler* products successfully completed testing to this standard. For details about specific working voltages and isolation ratings for each *iCoupler* product, and to view the safety certificates, please visit www.analog.com/iCouplerSafety.

Are *iCoupler* products sensitive to external magnetic fields?

No – unless such fields are *extremely* strong and of high frequency. Since the transformers used within *iCoupler* devices typically measure about 0.5 mm in diameter, it takes a very high magnetic field rate-of-change to induce a voltage large enough to cause a performance error. For example, if a wire carrying a current oscillating at 1 MHz were to be placed 5 mm away from an *iCoupler* transformer, the current amplitude that would be required in order to cause a problem with the *iCoupler*’s performance is 500A! (An analysis of this can be found in the Applications section of any *iCoupler* data sheet.)

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***iCoupler* Products**

What are the different types of *iCoupler* products?

iCoupler products are available in a variety of channel configurations and performance levels. Products consists of [single](#), [dual](#), [triple](#), and [quad](#) channel 2.5KV_{RMS} and [5.0KV_{RMS}](#) isolators each available in multiple performance/price options. Products are also offered with other features including:

- High Speed (150 Mbps) Quad Isolators ([ADuM344x](#))
- Default Low or Programmable Default Output ([ADuM1210](#), [ADuM131x](#), [ADuM141x](#))
- Increased EOS/ESD robustness ([ADuM3100](#), [ADuM320x](#), [ADuM330x](#), [ADuM340x](#))
- Isolated power (see *isoPower* below) ([ADuM524x](#))
- Dual and quad gate drivers ([ADuM1233](#), [ADuM1234](#))
- I²C ([ADuM125x](#), [ADuM225x](#))

- RS-485 ([ADM2483](#), [ADM2485](#), [ADM2486](#), [ADM2490E](#))
- $\Sigma\Delta$ Modulator ([AD7400](#), [AD7401](#))

Please refer to the *iCoupler* web site (www.analog.com/icoupler) for the most complete up-to-date selection table and other information about the *iCoupler* portfolio.

Which *iCoupler* product is best for my application?

Due to the unique nature of each application, the choice of which product to use is best left to the user. The selection tables available at www.analog.com/iCoupler should provide guidance for choosing the most appropriate *iCoupler* product. For additional assistance, please contact your local Analog Devices sales representative or distributor.

What communications protocols are supported by *iCoupler* products?

iCoupler products are capable of supporting most standard communications protocols but may require additional components to ensure communication integrity. Products such as the ADuM1401 are ideal for SPI where four channels are required for Clock, Data In, Data Out, and Select.

The ADuM125x and ADuM225x have been designed for compliance to the I²C, PMBus and SMBus protocols. The ADM2483, ADM2485, ADM2486 and ADM2490E are complete isolated RS-485 solutions.

What are some of the distinguishing features of the *iCoupler* products?

Distinguishing features of *iCoupler* products include integration that optimizes cost and size as well as the ability to support high signal data rates and the ability to operate with extremely low supply currents. *iCoupler* products provide an excellent cost/size advantage over competing alternatives due to integration of multiple channels as well as other functions including isolated power.

The speed and power consumption benefits can be seen in products such as the ADuM1100 that supports NRZ data rates of up to 100 Mbps and the ADuM344x that supports up to 150 Mbps.

iCoupler products also have the ability to perform up to a maximum temperature of 125° C and to be operated with either 3.3V or 5V supplies. Also of benefit to users is the incorporation of integrated driver circuitry providing compatibility with standard digital interfaces.

Can I replace an optocoupler with an *iCoupler* product in an existing design?

In most cases, an *iCoupler* product may be used as a replacement for an optocoupler in a given application in order to achieve higher performance, lower cost, greater space savings, or improved quality and reliability. In some cases, Analog Devices products are pin-for-pin compatible with industry standard optocouplers. For example, the ADuM1100, Analog Devices' first *iCoupler* product, is a single-channel digital isolator intended for applications requiring high-speed digital isolation. It is footprint- and pin-compatible with Agilent Technologies' HCPL-0710, -0720, 0721, -0723 optocouplers and provides substantial performance, power consumption, and cost advantages over these optocoupler components.

For all other products, please refer to the selection tables available at www.analog.com/iCoupler to identify the appropriate part. For assistance, please visit our web site or contact Analog Devices or one of our authorized sales representatives or distributors.

How do *iCoupler* products differ from interface products?

iCoupler isolation products are a subset of traditional interface products. Typically, a given *iCoupler* product may be suitable for a wide array of applications, whereas interface-specific products are limited in scope (e.g., RS-232 or RS-485 transceivers). In addition, interface-specific products may not require isolation; however, it is common that such interfaces also require some level of isolation. Analog Devices offers a variety of interface products, some of which integrate *iCoupler* technology for a fully integrated solution (see below).

Does Analog Devices provide other products that employ *iCoupler* technology?

A significant benefit of *iCoupler* technology is its ability to integrate isolation in a wide range of products. Integrating *iCoupler* isolation with other products simplifies designs, reduces the bill-of-materials, lowers cost, reduces size and increases reliability.

The ADM2483, ADM2485, ADM2486 and ADM2490E are RS-485 transceivers that employ *iCoupler* technology. Likewise, the AD7400 and AD7401 are isolated $\Sigma\Delta$ analog-to-digital converters. In the future, Analog Devices will release additional products integrated isolation via *iCoupler* technology.

Are *iCoupler* products Pb-free?

All *iCoupler* products are offered with Pb-free versions.

How do I learn about new *iCoupler* products?

Please visit the Analog Devices website at www.analog.com/icoupler for the most up-to-date information on new products. You

may also contact your local Analog Devices Sales representative. A quarterly newsletter, "Analog Devices' Digital Isolation Update," is also available. The newsletter includes new product announcements as well as news, application tips and technical information about the iCoupler technology. Please refer to www.analog.com/Subscriptions to learn how to subscribe to the "Analog Devices' Digital Isolation Update."

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isoPower[™]

What is *isoPower*?

isoPower refers to the Analog Devices technology that employs iCoupler technology to supply isolated power to systems via an integrated DC/DC converter.

What are common applications of *isoPower*?

isoPower is ideally suited for applications that need low levels of power that are isolated from a system's main supply. Such applications include:

- Factory automation equipment
- Secondary-control power supplies
- Medical systems

How does *isoPower* work?

isoPower uses the same underlying technology used in iCoupler products. Integrated transformer coils are employed in the equivalent of a fully integrated switching power supply. On-chip regulation ensures that the output supply is stable. By using the iCoupler technology, *isoPower* can be combined with standard iCoupler designs to create fully integrated solutions that include isolated power as well as isolated signals.

What are the benefits of *isoPower*?

The primary benefits of *isoPower* for system designers are:

- Lower cost
- Reduced area
- Improved time-to-market

The integrated DC/DC converter replaces multiple discretes in a system which reduces the size and design complexity. This, in turn, speeds time-to-market.

The benefits of *isoPower* are best realized in applications requiring a small, cost-effective source of localized, isolated power.

How much power to *isoPower* products provide?

Analog Devices initial *isoPower* products (ADuM5240/5241/5242) provide 50 mW of isolated power in an 8-lead SOIC package. Future products will provide higher amounts of power as dictated by market needs. Please refer to the selection table on our website at www.analog.com/icoupler.

What *isoPower* products are currently in production?

The ADuM524x is the first iCoupler product to feature *isoPower*. Released in 2007, it is a family of dual-channel isolators with 50 mW (5V / 10mA) of regulated, isolated power. Future iCoupler products with *isoPower* will have more data channels, supply more power and offer supply voltages other than 5V. For more information on the ADuM524x products, please refer to www.analog.com/ADuM524x.

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Support

Where can I find support for designing with ADI's iCoupler products?

Support for Analog Devices' products is available on-line at www.analog.com or through the Analog Devices' sales force or any authorized Analog Devices sales representative or distributor. For a full list of contact information, please visit the Analog Devices web site at: www.analog.com/salesdir to find a sales office near you.

For information on a specific product, please use the search feature on the Analog Devices web site to access the product page. The product page will have direct links to datasheets, application notes, technical articles and support tools (e.g., models).

An e-mail newsletter is published quarterly and provides updates on new products, application updates and other news. To subscribe to the newsletter, please visit our [eNewsletter Subscription Page](#).

I did not purchase iCoupler products from Analog Devices or an authorized distributor — how can I get support?

Analog Devices cannot support products that have been procured through unauthorized sources.

What do the iCoupler product datasheets guarantee?

Analog Devices data sheets adhere to a strict convention to ensure that products meet the published specifications. Unless otherwise noted, all parameters are guaranteed over the full range of conditions specified in the *Recommended Operating Conditions* section of a given data sheet.

Parameters are guaranteed to fall within the minimum and maximum specifications, where provided. Where parameters are specified as "Typical," customers may find that, in a reasonably sized population of units, half will fall above the typical value and half will fall below the typical value. Typical values are not guaranteed.

What tools or models exist to support my design?

Analog Devices currently provides IBIS models for most iCoupler products. Evaluation boards are also available for most products. Information on these tools can be found on the associated product pages.

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Last Updated: 11/2007