

Your Imagination. Our Innovation.



Isolation Product Solutions for Commercial and Industrial Applications



Application Reference

Isolation Products for Industrial Applications



In an industrial environment where high voltages, magnetic fields and noise are commonly present, reliability is critical to avoid downtime and ensure data accuracy. In this environment circuit designers use optocouplers to insulate high voltages and isolate unwanted signals. As the worldwide leader, Avago Technologies delivers optocouplers that are designed and manufactured to meet the stringent requirements of industrial applications. Our optocouplers comply with worldwide regulatory standards, including IEC (International Electrotechnical Commission), UL (Underwriters Laboratories, Inc.), CSA (Canadian Standard Association) and the EN (European Union) approvals.

Avago high-speed CMOS optocouplers are commonly used in Industrial Fieldbus applications with speeds of up to 50 MBd. The high linearity analog parts are suitable for systems that demand high accuracy, and our voltage detection parts detect and isolate interfaces. We also offer a lower speed family with speeds starting at 100 kBd for industrial I/O modules, as well as integrated gate drivers and current sense devices which are well suitable for motor control applications.

A wide range of the Avago isolation products are available to suit the various industrial applications. Together with our high CMR performance, high maximum insulation voltage and industrial temperature range, you can not go wrong when choosing Avago for your isolations needs.

**Avago Technologies
is the Worldwide
Leader in Isolation
Solutions for
Industrial
Applications**

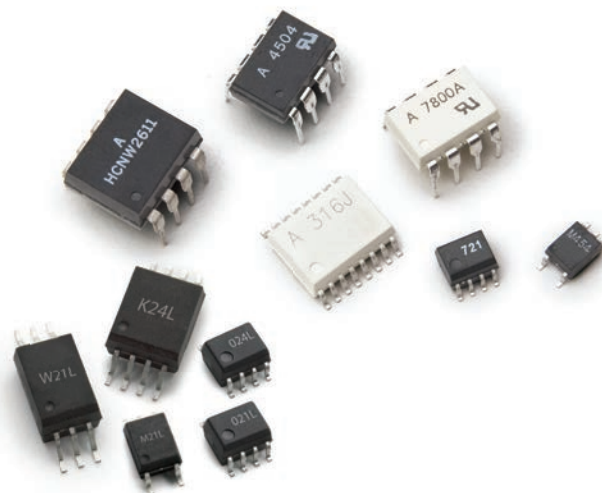
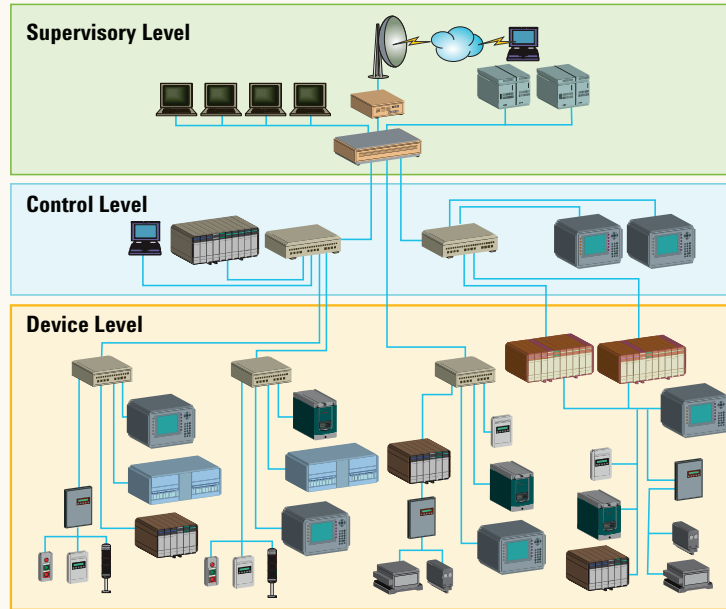


Figure 1. Three Primary Levels of an industrial applications.



- Supervisory Level
- Control Level
 - Discrete Serial Data Communication
 - Current Loop Communication
 - Industrial Universal Serial Bus
- Device Level
 - Digital I/O Interface in PC & PLC
 - AC/DC to Logic Interface
 - Isolated Analog to Digital Converter (ADC)
 - IGBT/MOSFET Gate Drive
 - Motor Control Feedback
 - IPM Gate Driver Interface

Solutions to your industrial isolation and insulation needs are now available in three primary levels, see Figure 1 for a full view of industrial applications.

Supervisory Level – Industrial Ethernet

Industrial networking requires a more robust and reliable standard compared to the office LAN (Local Area Network). These networks need to endure the harsh, factory floor environment, while providing reliability, security, and data accuracy (see Figure 2).

In industrial Ethernet networks that use twisted pair cables, isolation is needed between end-devices and the network to protect devices from voltage surges and ground loop currents. Avago high speed digital CMOS optocouplers, available at speeds of between 12 MBd and 50 MBd, can be used as an alternative to isolate transformers.

Figure 2. Networking Architecture.

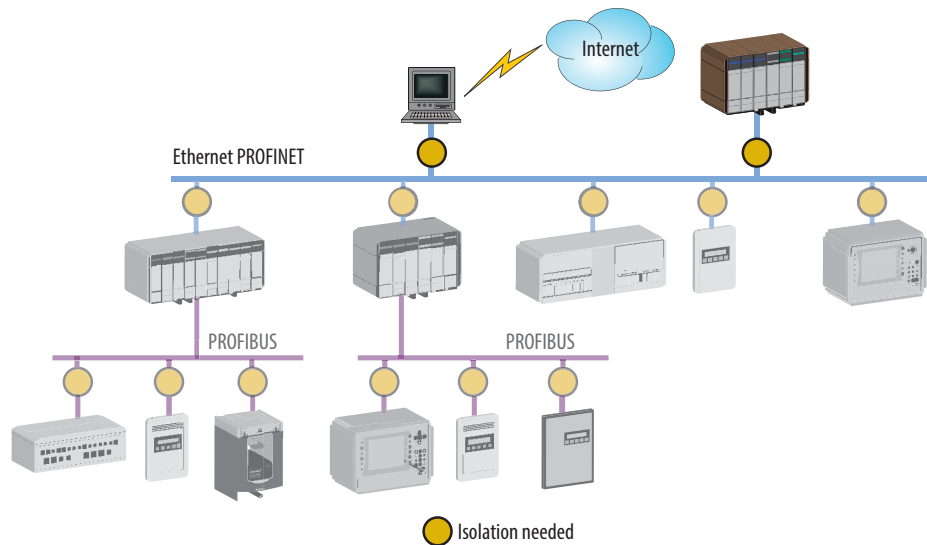
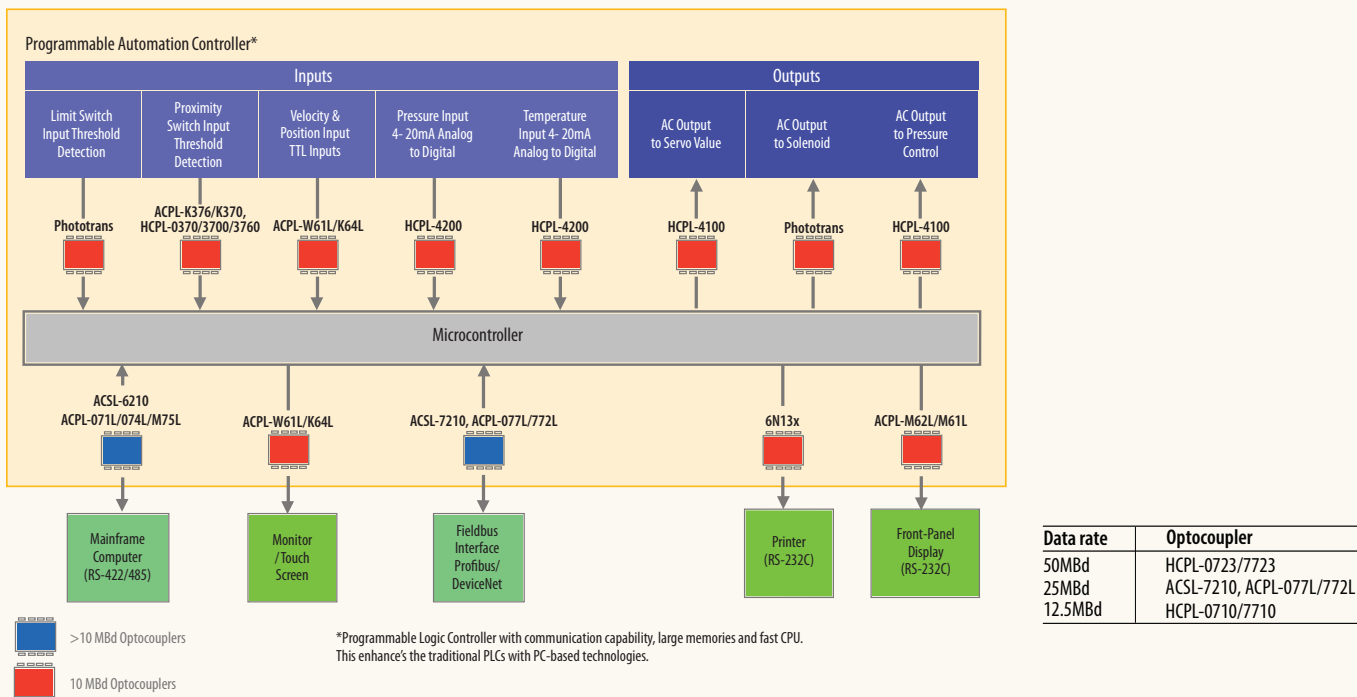


Figure 3. Programmable Automation Controller* block diagram.



Control Level

There are over 250 industrial networks today. Many of them employ small, proprietary protocols, although standards such as PROFIBUS and DeviceNet dominate the segment. At the control level (see Figure 1), communication between PLCs (Programmable Logic Controllers) and other PLCs; PLCs and HMIs (Human-Man Interface); and PLCs and SCADA (Supervisory Control and Data Acquisition), are very common.

Avago Optocouplers are used widely in PLC applications for isolation, especially in a factory environment where noise and magnetic inference are always present. As illustrated in the PLC block diagram (Figure 3), optocouplers can be used in Fieldbus modules, analog modules, digital modules, temperature controller modules, motor control modules and communication modules. From general purpose parts for multi-point discrete signals, to high speed CMOS parts for higher speed communications interfaces, to applications specific parts, users need features such as 4-20mA signal transmission. Avago is able to provide isolation solutions for all these applications.

Discrete Serial Data Communication

Avago digital optocouplers offer speeds from 100 kbd to 10 MBd/15 MBd (5V/3.3V). They are extremely important in serial digital data transmission and communications, such as RS-232, RS-422 and RS-485

The ACPL-074L (3.3V/5V, dual channels, 15 MBd) or ACSL-6210 (3.3V/5V, dual channels, bi-directional 15 MBd and ACPL-064L (3.3V/5V, dual channel, 10 MBd) provide isolation between bus transceivers and other digital logic with bus controllers (see Figure 4). Both parts meet serial data communication requirements such as noise elimination (due to high CMR functions) and low power consumption (due to low drive current) with high insulation voltage. Avago digital optocouplers are also offered in stretched packages (ACPL-W51L/K54L/W21L/K24L/W61L/K64L/W70L/K73L), which help to reduce 40-50% PCB board space as compare to DIP-8 packages.

Figure 4. Serial Bus Interface Isolation block diagram.

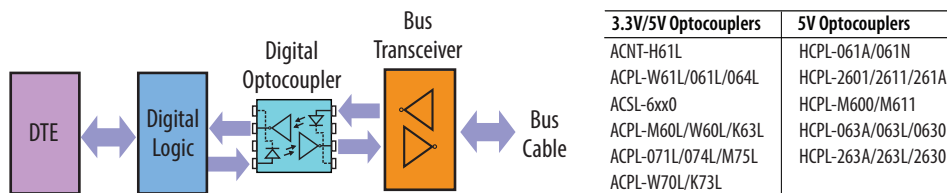
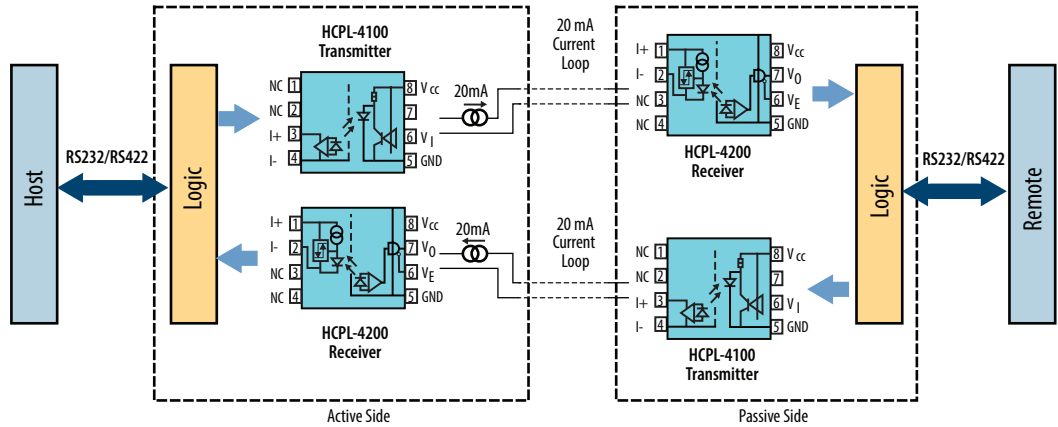


Figure 5. Current Loop Communication block diagram.



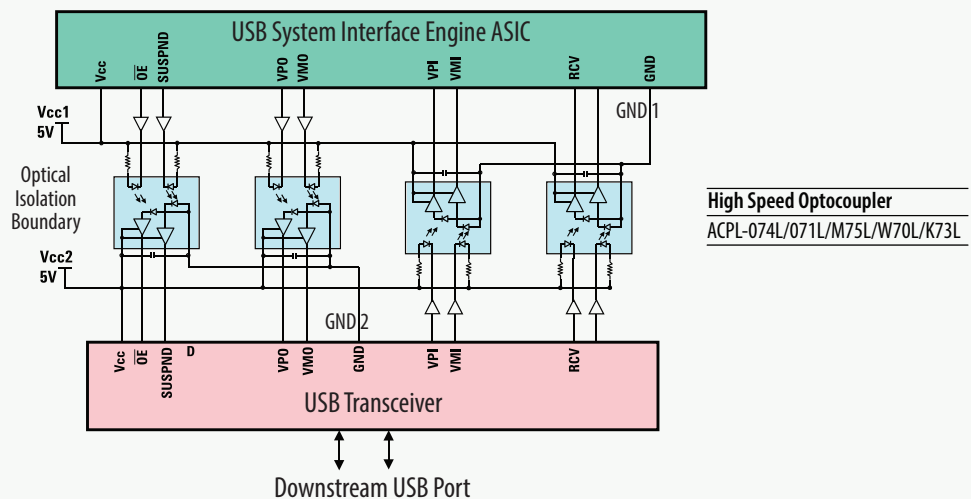
Current Loop Communication

Today's popular industrial-control applications, such as programmable logic controllers, factory process control, computer numeric control (CNC) and intelligent transmitters, require the use of 4-20 mA current loops. This has become a well-established part of the analog communications between the host computer and smart transmitters in a factory environment. For transmitting low-amplitude, low-frequency signals over a few hundred yards in a noisy industrial-control environment, current is preferred over voltage. This is because the current at any instant is constant over the entire length of the cable. The Avago HCPL-4100 and HCPL-4200 are designed to operate as a transmitter/receiver (see Figure 5) in equipment using 20mA current loop. Optical coupling of the signal from the logic input to the 20mA current loops breaks ground loops and provides a very high immunity to common mode interference as well as high voltage insulation and galvanic isolation for safety protection. Both the HCPL-4100 and HCPL-4200 are compatible with LSTTL, TTL or CMOS logic interfaces. The internal shield allows a guaranteed min 1000V/ μ s common mode transient immunity. The HCPL-4100 provides 20 kBd data rate at 40 meters line length while the HCPL-4200 stretches up to 1400 meters. Both are available in DIP8 packages.

Industrial USB

USB is intended to be used as a user friendly, hot plug and play bus for office environment. Integration from the control center to the factory floor has seen USB extended to devices meant for data acquisition and control using serial, parallel, Ethernet and other communications standards (see Figure 6). Due to the extension in length and the harsh industrial environment, optical isolation has to be used to prevent ground loops, spikes and surges. In this application, Avago small platform, S08 package, high speed digital CMOS optocouplers can be used to provide the necessary safety insurance to achieve the highest safety standards and reliability.

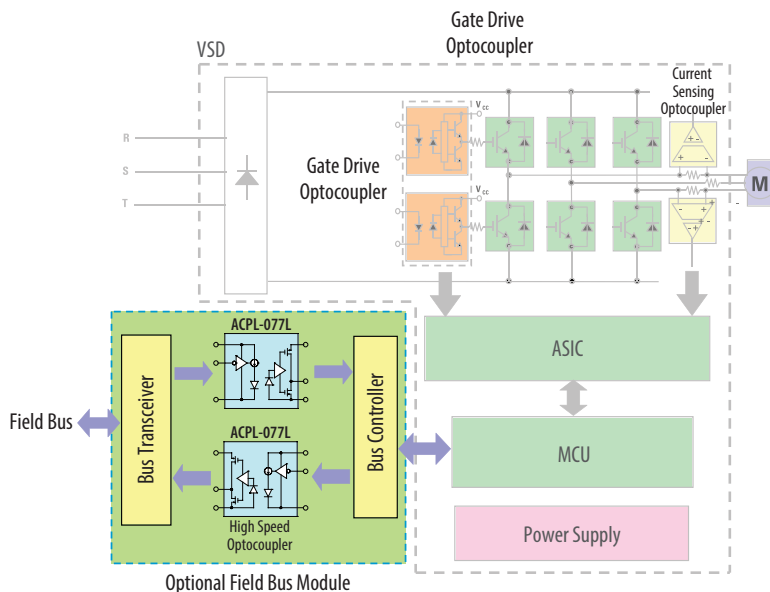
Figure 6. Industrial Universal Serial Bus block diagram.



Device Level – Smart Sensor and Smart Variable Speed Drive (VSD)

As industrial networking continues to evolve, we will see many significant improvements made at the device level. Data from the factory floor can be accessed almost instantly (determinism) at the main control center with just a touch of a button. Communications can be achieved with optional hardware, a Fieldbus option card mounted onto the end devices (e.g. VSD, or Temperature Controller). With this setup, the end devices can connect to the bus systems where data can then be transferred to and from the control center (see Figure 7).

Figure 7. Variable Speed Drive with Network Card block diagram.

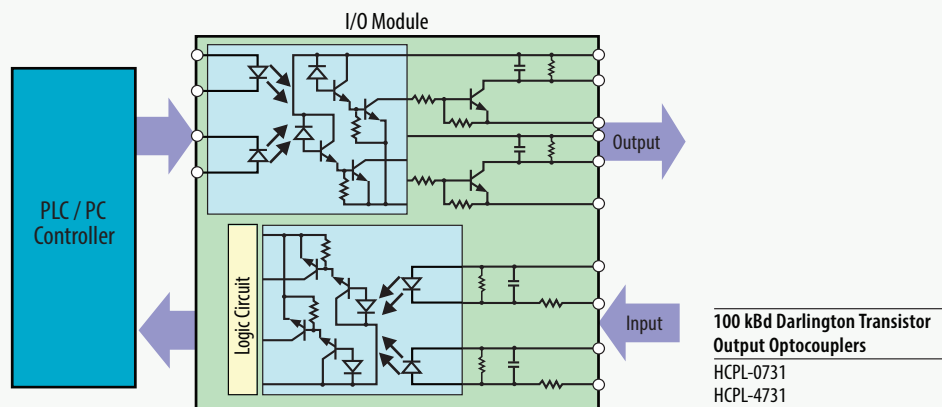


Avago optocouplers are used to protect the devices from high voltage in the bus line. The parts used are usually high-speed CMOS digital optocouplers for the option cards and gate drivers and current sensors for the VSD.

Digital I/O Interface in PC & PLC

Avago offers a wide range of low speed photo-IC 100kbaud optocouplers used in general purpose digital input/output signal isolation. The HCPL-0731 and HCPL-4731 are dual channel optocouplers that have a very low drive current. These optocouplers are designed into multi point I/O modules for PLCs or PCs (see Figure 8).

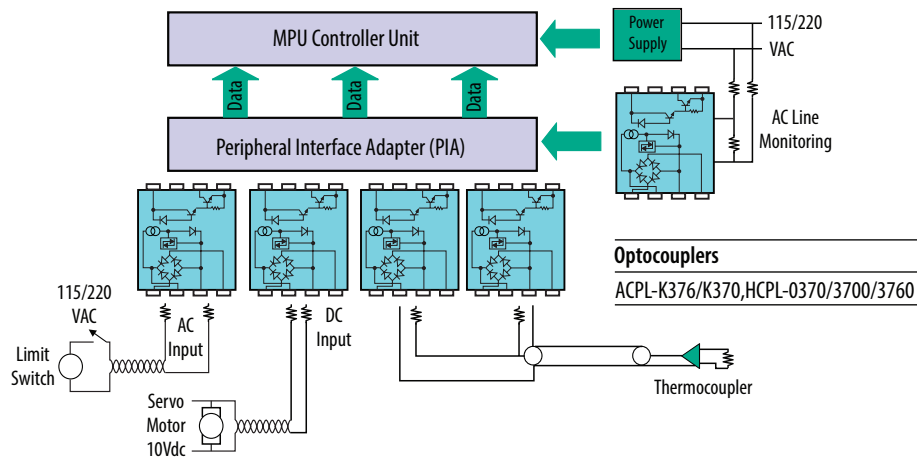
Figure 8. Digital I/O Module in Programmable Logic Controller (PLC) or Industrial PC.



AC/DC to Logic Interface

The use of electronic logic circuitry in most applications outside of a controlled environment can cause problems and hazards involved in interfacing between the logic function and the control function. These issues have always been particularly evident in the field of industrial control where the electrically 'noisy' environment produced by motors, power lines, lightning and other sources of interference may mask the desired signals, and some in cases even result in the destruction of the logic control system. Avago ACPL-K376/K370, HCPL-0370/3700/3760 (see Figure 9) are developed to address this logic interface problem. They are highly integrated AC/DC logic interface devices incorporating ease of design, low external component count, better predictability and reliability. These optocouplers incorporate AC/DC inputs for flexibility of input monitoring signals. The low input current version ACPL-K376, HCPL-3760 offers excellent operating efficiency, as the LED provides high light output at lower drive current. In addition, the hysteresis buffer provides threshold sensing which permits control of threshold levels over a wider range of input voltages with a single external resistor. DIP 8 and SO8 packages are available.

Figure 9. Industrial Monitoring Control block diagram.



Isolated ADC

Analog signals detected from sensors which measure temperature, pressure and weight are converted to digital data and transmitted to a controller via fieldbuses. The Avago high speed digital CMOS parts, the HCPL-0720/0721/0723 and ACSL-7210, ACPL-077L/772L are recommended for this application. For isolated ADC applications, the optocouplers are connected between the ADC chip and the microprocessor (see Figure 10 and 11). They break ground current loops and eliminate noise from differences in ground potential. This is usually critical in high speed and high accuracy analog to digital data conversion. The wide range of Avago high-speed optocouplers are applicable to both serial and parallel A/D converted data streams.

Figure 10. Parallel A/D conversion Isolation.

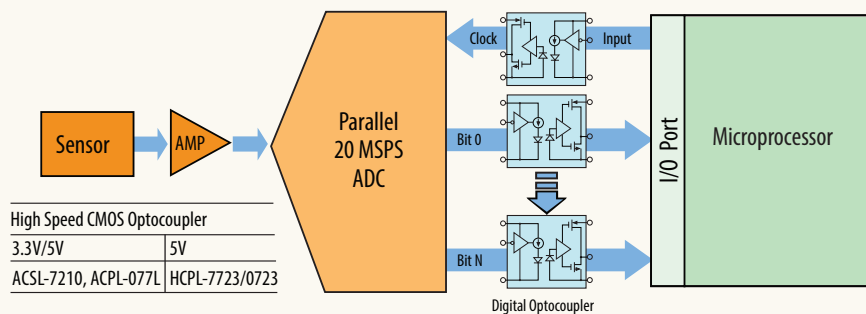
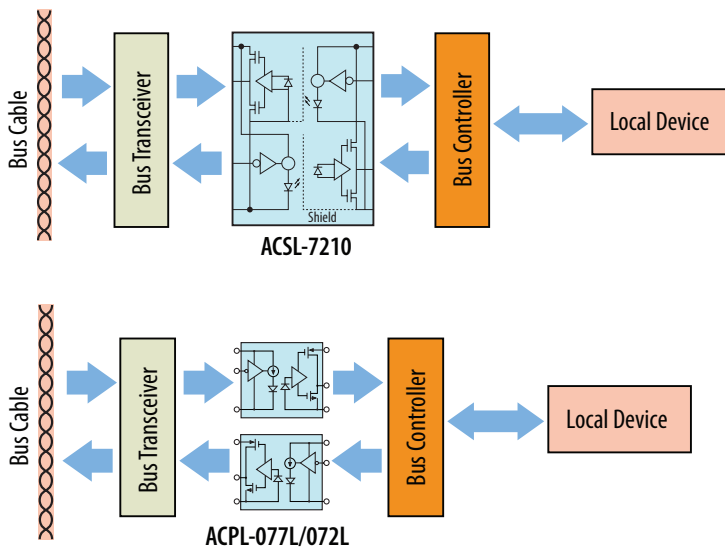


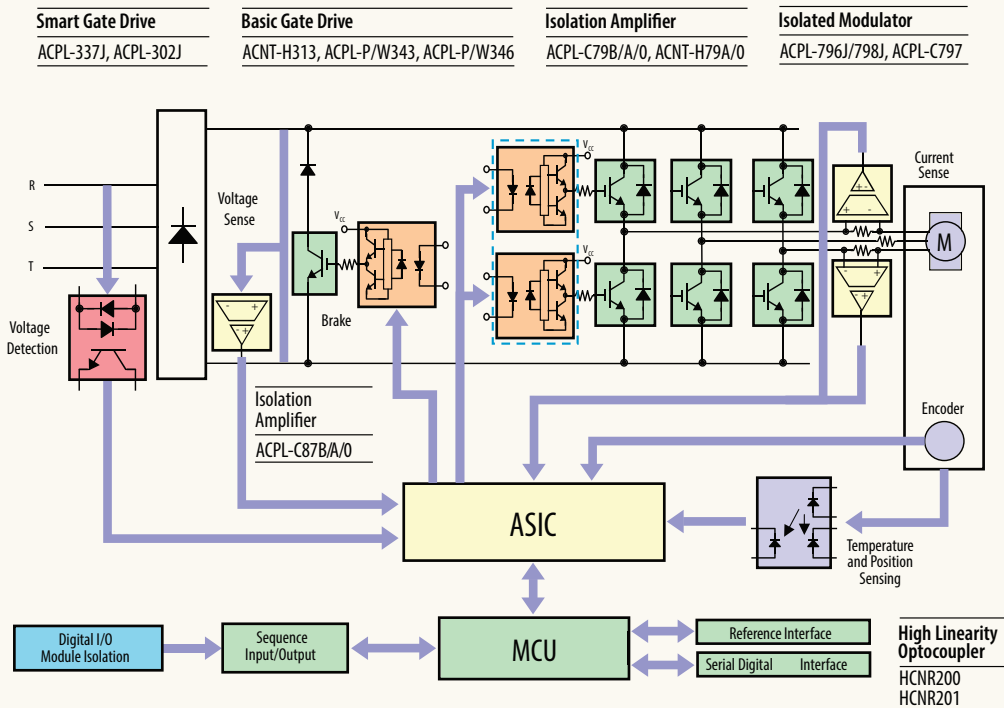
Figure 11. Fieldbus Networks (PROFIBUS/RS485/DeviceNet/CAN).



IGBT, MOSFET(Si/SiC/GaN) Gate Drive

IGBT/MOSFET power devices in power conversion stages switch high voltage/current in equipment such as AC and brushless DC motor drives, renewable energy inverters, industrial inverters and switching power supplies. The Avago gate drive optocoupler portfolio has a maximum output current ranging from 0.4A up to 5A, high CMR rating up to 50kV/ μ s and IGBT protection features. The Avago gate drive optocouplers, such as the ACPL-33xJ, ACNT-H313 and ACPL-P/W34x, provide isolation for direct drive power devices, and isolate low voltage control system's MCU/PWM controllers from high voltage power devices (see Figure 12).

Figure 12. 3-Phase Motor block diagram.



The ACPL-337J device features a 4A rail-to-rail output while the ACPL-302J an integrated flyback controller for DC-DC converters. Both are “smart” gate drivers with active Miller clamp, IGBT DESAT detection, and Under Voltage Lock-Out (ULVO) with feedback providing a complete fail-safe cost-effective gate drive solution.

The ACNT-H313 features the industry’s highest rated peak working voltage (VIORM) of 2,262 V in a compact 14.2mm stretched SO8 package, enabling high voltage insulation and protection in space-constrained applications. The ACNT-H313 is ideal for use in high -voltage applications such as the emerging 690VAC motor drives, traction, medical, and centralized renewable energy inverters.

The ACPL-P/W343(4A) and ACPL-P/W346(2.5A) are basic gate drivers targeting specifically for IGBT and MOSFET drive respectively. The ACPL-P/W346 has the fastest maximum propagations delay of 120ns suitable for high frequency operation.

Fieldbus Networks

With the advent of digital fieldbus communication networks such as DeviceNet, PROFIBUS and Smart Distributed Systems (SDS), it is recommended to provide galvanic isolation using high speed optocouplers. The isolated nodes would employ devices with serial/parallel ports, RS232/422/485. With the popular trends of 3.3V or lower, the Avago ACSL-7210, ACPL-077L/772L is the industry’s fastest 3.3V/5V optocoupler transmitting data at minimum guaranteed speed of 25 MBd. It also features low pulse width distortion of 6ns and built-in level shifter for operation in dual voltages. ACPL-x2xL, ACPL-M51L* are the 5 MBd, 1 MBd optocouplers operating at 2.5V supply voltages.*

Motor Control Feedback

The most common circuit for driving a motor is, as shown in Figure 12, an inverter. A typical inverter takes power from a high-voltage dc line, then rapidly switches on and off to approximate a smooth sinusoidal ac voltage appropriate for driving an electric motor. The six basic applications in motor control inverter systems that use optical isolation technology are the power switch, voltage sensor, current sensor, temperature feedback, position sensing and data communication circuits.

Advanced motor drivers like inverter or servo motor apply close loop/vector control technology through phase current feedback. For many years, Avago isolation amplifiers (HCPL-7800A) and isolated modulators (HCPL-7860) are the de facto current sensing devices. They provide high linearity and resolution across the industrial operation temperature range. They are also optimized for general current and voltage sensing. Newer generation devices like the ACPL-796J/798J, ACPL-C797 isolated modulator, ACPL-C79B/A/0, ACNT-H79A/0 isolation amplifiers and ACPL-C87B/A/0 isolated voltage sensors helps to further improve the overall system performance.

The ACNT-H79x features the industry’s highest rated peak working voltage (VIORM) of 2,262 V in a compact 14.2mm stretched SO8 package and is ideal for use in high voltage applications.

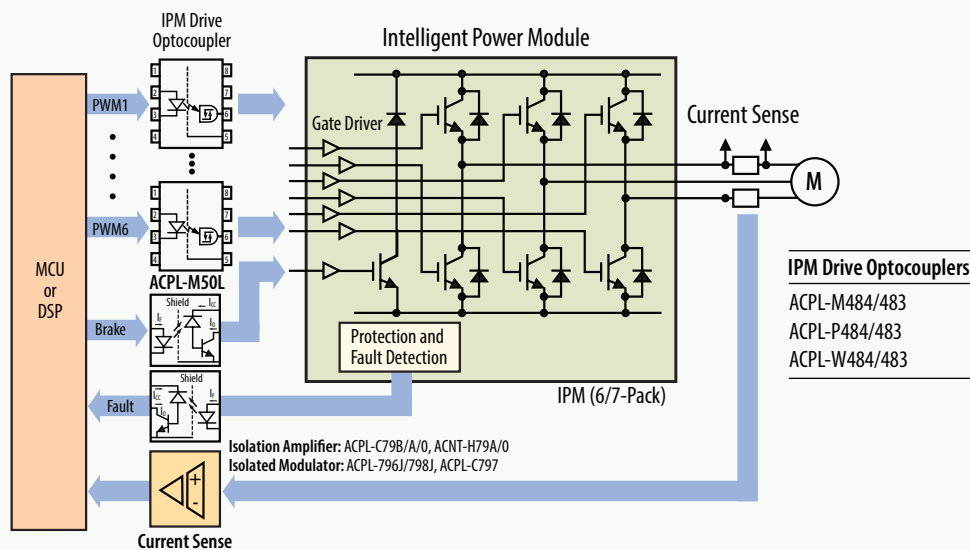
The HCNR200/201 can be used to isolate analog sensing signals in the motor temperature and position feedback loop, requiring excellent signal stability, high linearity and bandwidth. The HCNR200/201 is very flexible and capable of operating in many different modes, including unipolar/bipolar. The high accuracy and wide dynamic range of the temperature and position circuit is achieved by using a low cost precision op-amp that interfaces to the micro-controller. Both devices have a non-linearity of 0.01%, transfer gain of $\pm 15\%$ and $\pm 5\%$ respectively, and are available in DIP8/SMD Gullwing packages.

* Denotes advance information at the time of print.

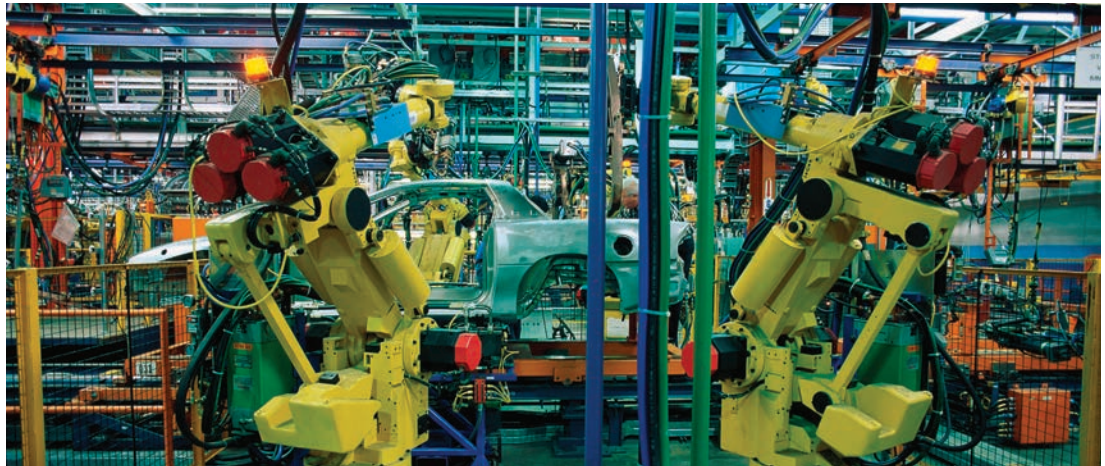
IPM Gate Driver Interface

Intelligent Power Modules (IPMs) integrates gate drive circuits with IGBT power devices. The ACPL-M/P/W484 and ACPL-M/P/W483 with HVCMR of 30kV/μs at 1kV-Vcm and propagation delay of 120ns maximum, is considered the fastest IPM optocoupler in the market. This device has a built-in schmitt trigger that provides logic compatible waveforms that eliminate the need for additional wave shaping, a totem pole output so that a pull up resistor is not required, and a positive input/output logic inverter. This device also comes with a high output driving current capability of up to 125mA. These 10 MBd logic optocouplers are extremely important in providing isolation between MCU/PWM controllers and IPMs (see Figure 13). They are designed with low drive current and have high insulation voltage (3750/5000V), a wide operating temperature range (-40 to 105°C), and a wide supply voltage range (4.5 to 30V) which meets IPM industrial requirements.

Figure 13. Inverter Motor Drive.

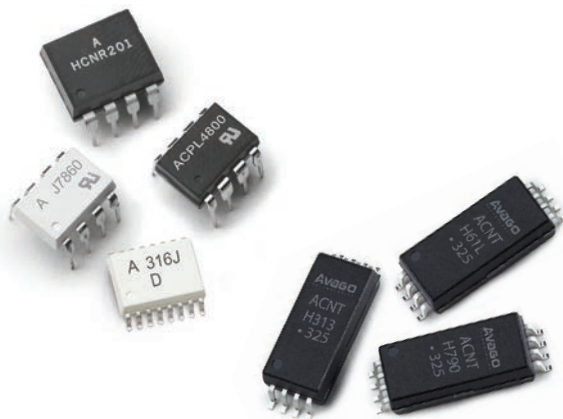


Isolation Products in Motor Control Systems



Today's highly competitive market demands motor control solutions that offer higher performance, greater functionality and efficiency, and reduced cost. In a motor drive system where high voltages, magnetic fields and noise are commonly present, reliability is critical to avoiding downtime. Optocouplers are used to insulate high voltages and isolate unwanted signals. A wide range of isolation products from Avago Technologies are now available to suit a range of motor control applications.

Avago Technologies offers the most comprehensive line of Intelligent Power Module (IPM) Interface Optocoupler, Integrated Gate Drive Optocoupler and Miniature Isolation Amplifier solutions. Its leading Digital Optocoupler products are highly robust and reliable - even in the harshest environments - and feature leading isolation technology and Common-Mode-Rejection-Ratio (CMR) performance. Avago Technologies' high-linearity analog parts are suitable for systems demanding high accuracy, while its voltage-detection parts detect and isolate interfaces. Avago optocouplers fully comply with regulatory standards worldwide, including IEC (International Electrotechnical Commission), UL (Underwriters Laboratories, Inc.), CSA (Canadian Standard Association) and EN (European Union) approvals. For your motor control system isolation needs, you can't go wrong by choosing Avago Technologies.



Main Components of Motor Control System

In a motor control system there are typically 5 key components: a controller with I/O interface block, gate drivers, sensors, an inverter (power stage), and a motor (Figure 1). The controller (usually an MCU, DSP or embedded processor) processes the requirements of the application, such as torque, speed, direction, and position, and converts this information into a Pulse-Width-Modulation (PWM) signal that is fed to the gate driver. The gate driver turns on the power inverter transistors (IGBT/Power MOSFET/IPM) at very high switching frequency; thereby allowing current to flow. This current then drives the motor at variable speeds, depending on the user-specified target speed. For a stable system, a closed-loop feedback on current, shaft position, temperature, speed, rotation direction, and back EMF is required.

Power Stage

Integrated Gate Drive Optocouplers

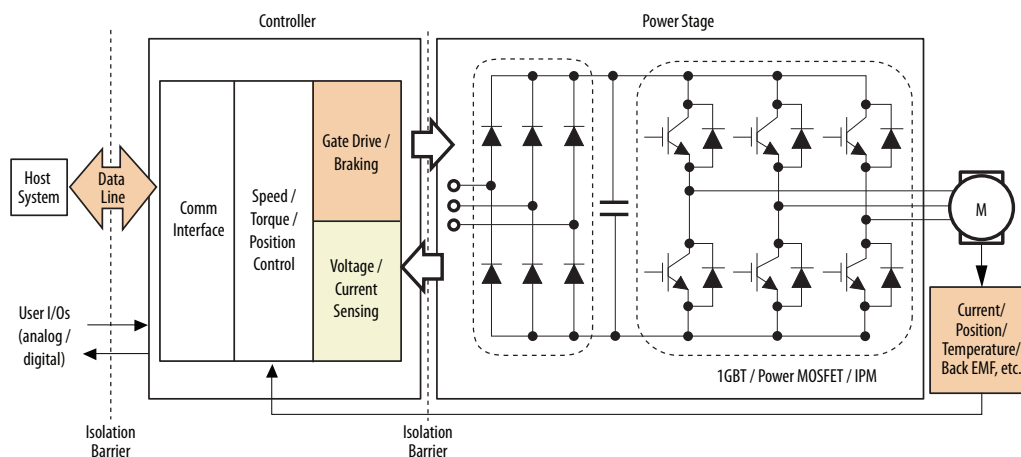
A motor control system adjusts the speed, direction of rotation and position of the motor shaft by varying either the voltage applied to the motor or the current that flows through the motor. In modern motor-control-system design, power switching elements (e.g. a power transistor, MOSFET, IGBT, or IPM) are commonly used to regulate the motor supply voltage. The motor's speed, direction and position is precisely controlled by turning the power switching elements on/off and altering the supply voltage using a PWM signal controlled by the MCU. Because the gate driver circuitry turns the power switching element on/off, it is considered a critical component of modern motor control technology.

The two most popular categories of discrete power switching elements for motor control are power MOSFET and IGBT. Wide band gap semiconductor like the Silicon Carbide(SiC) and Gallium Nitride (GaN) are emerging power MOSFET devices. Both the power MOSFET and IGBT are voltage-controlled devices. Switching (turning the device on/off) is controlled by applying voltage to the gate of the device (e.g. gate drive). In addition to meeting the severe requirements for the isolation function, the Avago Integrated Gate Drive Optocouplers provide customized functionality such as direct gate drive for IGBTs or power MOSFETs, and IGBT desaturation protection (Figure 2).

IGBT/MOSFET power devices switch high voltage/current in the power conversion stage of a motor control system. The Avago gate drive optocoupler portfolio has a maximum output current ranging from 0.4A up to 5A, high CMR rating up to 50kV/ μ s and IGBT protection features.

Drive optocouplers, such as the ACPL-33xJ, ACNT-H313 and ACPL-P/W34x, provide isolation for direct drive of the power devices.

Figure 1. Motor Control System Block Diagram.



The ACPL-337J device features a 4A rail-to-rail output while the ACPL-302J is an integrated flyback controller for DC-DC converters. Both are “smart” gate drivers with active Miller clamp, IGBT DESAT detection, and Under Voltage Lock-Out (ULVO) with feedback providing a complete fail-safe cost-effective gate drive solution. The ACNT-H313 features the industry’s highest rated peak working voltage (VIORM) of 2,262 V in a compact 14.2 mm stretched SO8 package, enabling high voltage insulation and protection in space-constrained applications. The ACNT-H313 is ideal for use in high -voltage applications such as the emerging 690VAC motor drives, traction, medical, and centralized renewable energy inverters. The ACPL-P/W343(4A) and ACPL-P/W346(2.5A) are basic gate drivers targeting specifically for IGBT and MOSFET drive respectively. The ACPL-P/W346 has the fastest maximum propagation delay of 120ns suitable for high frequency operation.

IPM and Gate Drive Interface Optocouplers

In addition to discrete power switch elements, Intelligent Power Modules have become popular in advanced motor control design, such as in the inverter. An IPM consists of high-performance IGBT power devices with integrated gate drive and protection circuits in one package. The advantages of the IPM include reduced design time, smaller size and improved reliability and manufacturability. Avago IPM and gate drive interface optocouplers provide isolation between MCU/PWM controllers and IPMs. Examples include the industrial fastest 10MBd ACPL-M484/483 and ACPL-P/W484/483 which come in very small SO5 and Stretched SO6 package respectively. These devices have a totem pole output which eliminates the need for a pull-up resistor and have a 125mA output current drive which allows for direct IPM drive. They are designed with low drive current, high CMR capabilities and insulation voltage, and operate over a wide temperature range (-40 to 105°C). Both devices also feature a wide supply voltage (4.5 to 30 V), which meets current IPM industrial requirements.

Figure 2. ACPL-302J IGBT Gate Drive Circuit with Desaturation Protection and Integrated Flyback Controller for DC-DC converter.

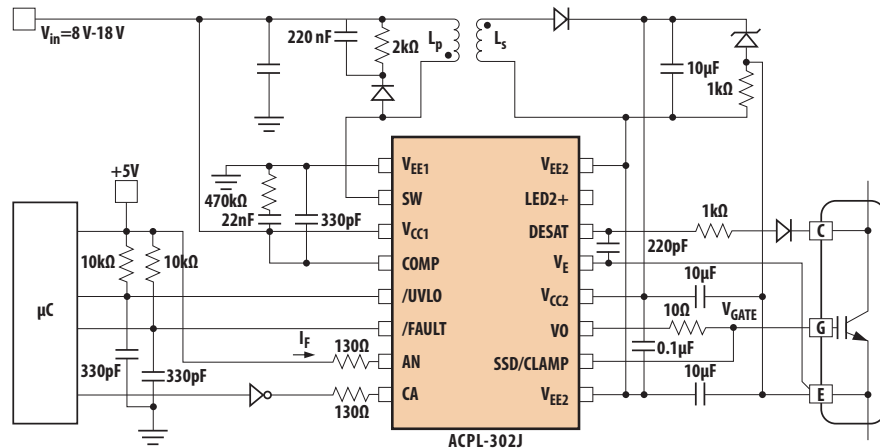
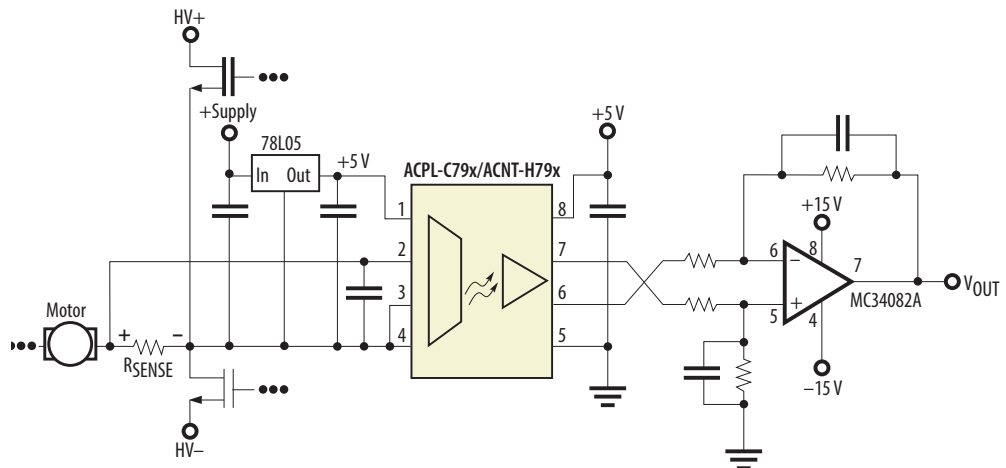


Figure 3. Optically Isolated Current Sensing Circuit with ACPL-C79x/ACNT-H79x Isolation Amplifier.



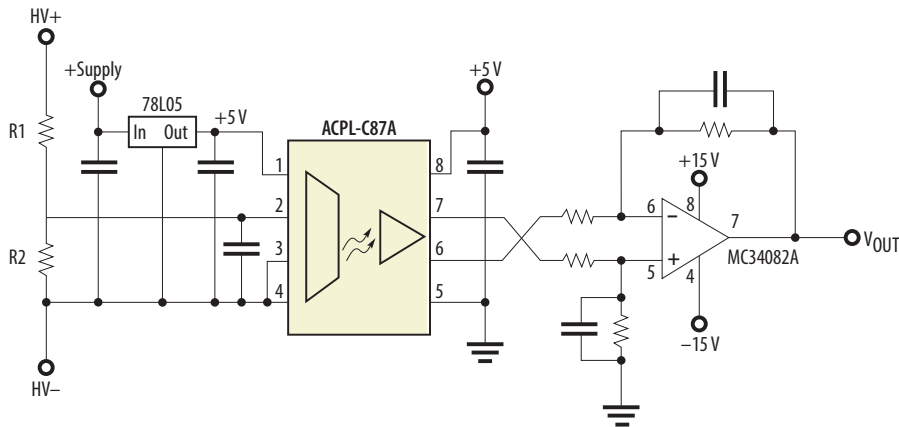
Feedback and Protection

Bus and Phase Current Feedback

Isolating the precision analog signal from the motor current-sensing element is an ongoing challenge facing circuit designers. The Avago high CMR isolation amplifiers are a cost effective replacement for traditional motor sensing devices (e.g. Hall-Effect devices). Even in an extremely high electrical noise environment, they provide both the precision and stability needed to accurately monitor motor current for tighter control in motor control applications. The ACPL-C79x isolation amplifiers require a simple interface circuit which includes a current sensing resistor (Figure 3). Compared to Hall-Effect sensors, ACPL-C79x have excellent gain and offset characteristics, including very low drift over temperature. These devices also feature a very high CMR specification of 15,000 V/ μ s at 1000-V_{peak} voltage. They are not affected by external magnetic fields and do not exhibit residual magnetization effects which may affect offset. These versatile features enable the designer to use the same circuit and layout for sensing different motor current ranges; all that's required is a simple substitution of different current-shunts. Such functionalities make ACPL-C79x and ACNT-H79x excellent choices for sensing current in a wide range of motor control applications up to 200 A or more. The ACNT-H79x features the industry's highest rated peak working voltage (VIORM) of 2,262 V in a compact 14.2mm stretched SO8 package, is ideal for use in high voltage applications.

The Avago HCPL-788J, HCPL-7510 and HCPL-7520 isolation amplifiers are recommended for circuit designers who want to have a single-ended output to interface directly with the A/D port of the microcontroller. For even higher higher system accuracy, isolated modulators like the ACPL-796J/798J and ACPL-C797 allows a direct modulated output bitstream to be interface directly to a MCU or FPGA. The baseband signal can then be easily recovered through a simple digital filter implementation.

Figure 4. Optically Isolated Voltage Sensing Circuit with ACPL-C87A Isolation Amplifier.



DC and AC Voltage Feedback

The ACPL-C87X voltage sensor is often used in photovoltaic (PV) panel voltage measurement and tracking in PV inverters, and DC bus voltage monitoring in motor drivers. The high voltage across rails needs to be scaled down to fit the input range of the iso-amp by choosing R1 and R2 values according to appropriate ratio. Figure 4. shows an example of how the ACPL-C87X senses the single-ended input signal and produces differential outputs across the galvanic isolation barrier. The differential outputs (V_{OUT+} , V_{OUT-}) can be connected to an op-amp to convert to a single-ended signal or directly to two ADCs.

The Avago ACPL-K376/K370, HCPL-0370/3700/3760 Threshold-Sensing Optocoupler can be used for sensing the AC/DC power on/off condition (Figures 5 and 6). To limit the current, a pair of series resistors (RX/2) is required at the optocoupler input. The AC signal can be filtered with a capacitor at either the input or the output of the optocoupler. The value of RX determines the threshold sensing voltage.

Analog Isolation for Temperature, Back EMF, Back EMF Zero Crossing, Speed, and Positioning Feedback

The high linearity analog optocoupler, HCNR201, can be used as a high-speed, low-cost isolation amplifier in the feedback of temperature, back EMF, back EMF zero crossing, speed, positioning and others. It is ideal for use in applications where high bandwidth, low cost, and stable gain are required, but where accuracy is not critical. A common schematic of the analog optoisolation block is shown in Figure 7.

Figure 5. ACPL-K376/K370, HCPL-0370/3700/3760 AC Input Configuration.

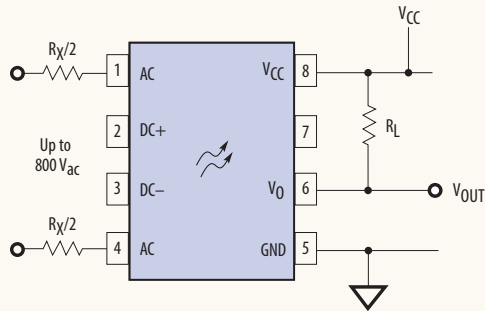


Figure 6. ACPL-K376/K370, HCPL-0370/3700/3760 DC Input Configuration.

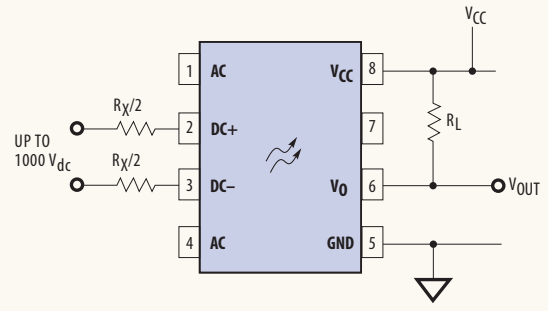
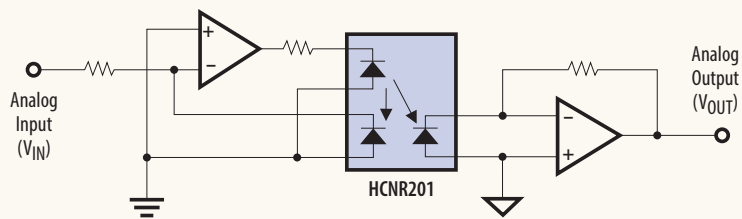


Figure 7. Simplified Analog Isolation Block.



Connectivity

Besides user I/Os for local control, a motor control communication interface provides connectivity between the motor control unit and host system in an industrial control and automation environment. Fieldbus and networking technologies, based on dedicated twisted pair cables or RS-485 cabling, are commonly used in the motor control digital communication interface.

The interface devices used in a motor control system, especially those used in industrial applications to transmit data throughout the network or portion of the system through the bus line, need to be robust and reliable to perform in typically harsh environments. High CMR performance and isolation voltage are a few of the features highly desirable in these applications. Avago optocouplers provide the necessary electrical isolation required in this environment. The Avago offering includes miniature surface-mount optocoupler packages for high-density applications, as well as multi-channel, bi-directional optocouplers.

Serial Bus Interface Isolation RS-232, RS-422 and RS-485

Avago digital optocouplers offer speeds from 100 kBd to 10 MBd/15 MBd (5 V/3.3 V) and are used in serial digital data transmission and communications, such as RS-232, RS-422 and RS-485 (Figure 8). Two such devices, ACSL-6210 (3.3V/5V, dual channels, 15 MBd) and ACPL-074L (3.3V/5V, dual channels, 15 MBd), provide isolation between bus transceivers and other digital logic with bus controllers. Both parts meet serial data communication requirements such as noise elimination (due to high CMR functions) and low power consumption (due to low drive current) with high insulation voltage. Avago digital optocouplers are offered in stretched packages (ACPL-W50L/K54L/W21L/K24L/W61L/K64L/W70L/K73L). The ACNT-H61L is a low power 10 MBd digital optocoupler for system control and data communications isolation, offer 14.2 mm creepage and clearance for high voltage applications. ACNT-H61L is able to achieve 2,262 VPEAK insulation working voltage in a stretched compact SO-8 package.

Fieldbus Networks Profibus/RS-485 and DeviceNet/CAN

The Avago high-speed CMOS optocouplers are commonly used in Industrial Fieldbus applications with speeds of up to 50 MBd. These optocouplers use the latest CMOS IC technology to achieve outstanding performance with very low power consumption. In the isolated multipoint transmission application circuit shown in Figure 9, two different optoisolators are utilized (ACPL-077L), or 1 bi-directional dual-channel optoisolator (ACSL-7210). Benefits of this configuration include low input drive current that maximizes Light Emitting Diode (LED) lifetime/reliability and optimized speed for Profibus and RS-485 applications.

Figure 8. Serial Bus Interface Isolation Block Diagram.

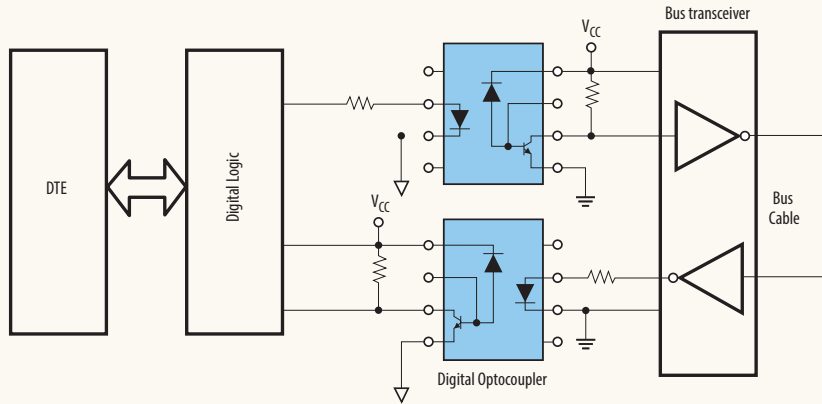
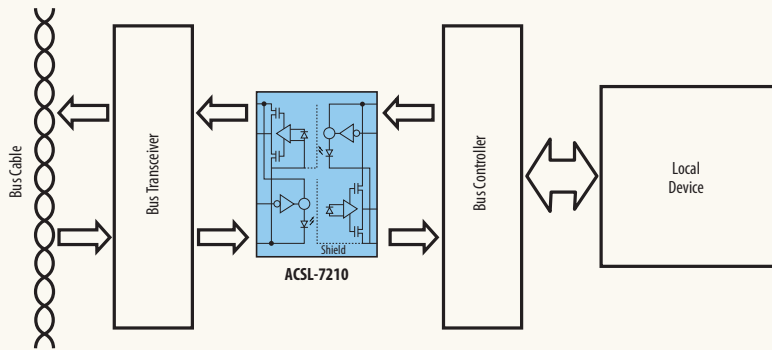


Figure 9. Fieldbus Network Profibus Block Diagram.



14.2mm Wide Creepage and Clearance Optocouplers for High Voltage Applications

The ACNT family of wide optocouplers offers 14.2mm creepage and clearance for high voltage applications. These optocouplers are able to achieve 2,262 VPEAK insulation working voltage in a stretched compact SO-8 package. To address the needs for a comprehensive isolation solution in high voltage and noisy environment, the ACNT family consists of three products: the ACNT-H313, a high efficiency gate drive optocoupler for driving IGBTs; the ACNT-H61L, a low power 10 MBd digital optocoupler for system control and data communications isolation; and the ACNT-H790, a high linearity isolation amplifier for current and voltage sensing applications.

Creepage and Clearance Requirements

Today high-voltage power systems require chip-level components to support well insulated and noise-immune large signals to minimize copper wiring costs while maintaining optimal power efficiency. In the drives systems, the benefits of using 690 VAC line voltage are power efficiency with power increases without current increases and lesser copper losses. This saves overall system costs in term of cable size, transformer size and installation cost. According to the adjustable speed electrical power drive system safety IEC 61800-5-1 (ref IEC 60664-1), to determine the creepage requirements for a working voltage of the drive, design engineers need to consider several factors such as insulation type (basic or reinforced), pollution degree, and insulation material group. The factors of impulse voltage, working voltage and altitudes dictate multiplication factor and requirement for clearance. Table 1 shows various market segments with the required creepage and clearance distance needed for pre-determined bus and working voltages. For example, a working voltage 630 VAC drive system with DC bus voltage 1200 V, pollution degree 2 and insulation material group III, requires 12.6mm minimum creepage for reinforced insulation.

Revision in the regulatory standards can call for wider optocouplers need. For example, from 2016, the harmonization of international standard bodies UL and IEC transits UL 508C to IEC 61800-5-1 will mean more stringent creepage and clearance requirements for new drive model while maintaining the same rating specifications. The ACNT family suits well to meet this revision and implementation.

The Avago ACNT family provides a complete isolation solution of a motor control system as shown in Figure 10. To isolate the low voltage “brain” or MCU and the high voltage power electronics, the ACNT-H313 2.5A gate driver suits driving power IGBTs and MOSFETs with excellent commonmode rejection noise performance of 40 kV/ μ s at 2000 VCM. For the isolated motor phase current and voltage measurements, the ACNT-H790 isolation amplifier offers $\pm 3\%$ gain tolerance with excellent linearity and dynamic performance of 60 dB SNR. Its specifications of 200 kHz bandwidth and 1.6 μ s fast response time allow capture transients in short circuit and overload conditions.

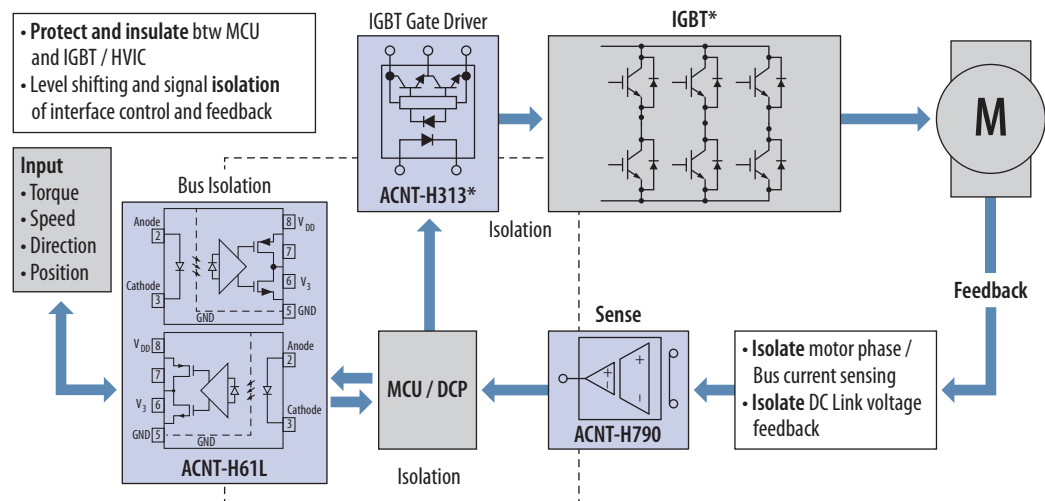
For data bus communication isolation or to simply provide isolation between low voltage control and high voltage power (eg. HVIC or IPM), the ACNT-H61L digital 10 MBd optocoupler offers the lowest power consumption (less than 20mW) 14.2 mm optocouplers available in the market.

Table 1. Market segments with wide creepage and clearance trend.

Market	Bus Voltage	Creepage and Clearance*
690VAC Drives	1200V	>12mm
Wind Inverter	1200V	12mm
Medical (480VAC)	1200V	>12mm
Central Inverter	1700V	>14mm
Solar Inverter (Multi-Level SiC)	1000V	8mm

* Depend on factors such as working voltage, insulation type, pollution degree, and insulation material group

Figure 10. A complete Isolation Solution in the Motor Control System.



* For HVIC use, digital optocoupler ACNT-H61L isolates the control (MCU / DSP) and HV power electronic blocks.

Table 2. ACNT Family Optocouplers Value Propositions.

Market	Bus Voltage
VIORM = 2,262 VPEAK VISO = 7,500 VRMS	Market's highest insulation voltage 2262 VPEAK optocouplers in 14mm creepage/clearance Certified high insulation voltage for robust, reliable and safe fail reinforced insulation
14.2mm creepage and clearance	Meets stringent system/equipment regulatory requirements
Low power <20mW	Market's lowest power consumption 10MBd optocoupler in 14mm creepage/clearance Energy efficient. (ACNT-H61L)
High noise immunity CMR (40kV@VCM=2,000V)	Prevent erroneous driving IGBT in noisy environment (ACNT-H313)
Low gain drift -50ppm/°C and 0.05% linearity	Advanced Sigma-Delta A/D modulation technology and full differential isolation to enhance accuracy (ACNT-H790)

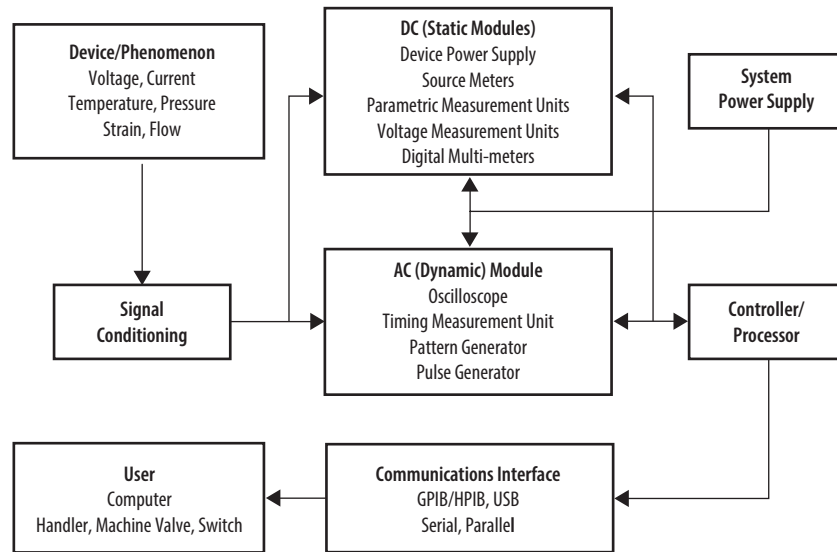
Avago Technologies Isolation Products Offer Solutions for Test and Measurement



For the test and measurement market, it can broadly be segmented into instrumentation, automated test equipment and data acquisition systems. The building blocks are similar in all three segments, and isolation products can be found in the various blocks.

In general, isolation products play an important role in test and measurement. They improve signal isolation and measurement accuracy through common mode rejection and system noise reduction, enable ease of design by breaking ground loops and provide safety with excellent high voltage insulation.

Figure 1. Building Blocks of a Test and Measurement System.



Area of Applications

The common building blocks in test and measurements (see Figure 1) can be arranged as signal conditioning module, which feeds into DC (static) and AC (dynamic) modules, which subsequently transmit the results to a controller or processor that outputs to the end user through the communications interface module. These are all powered by the system power supply module.

DC Modules

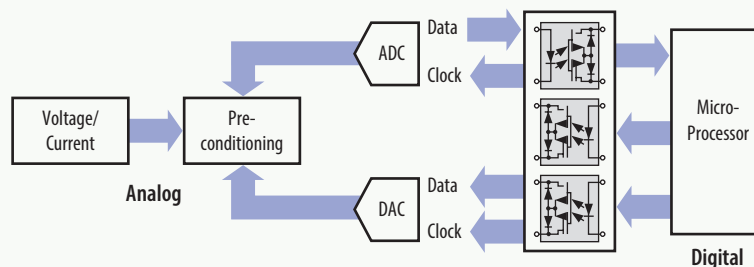
Example of DC modules could be pin electronics, parametric measurement units, voltmeters, ammeters, multi-meters, device power supplies, voltage sources and current sources. In these individual modules, there will typically be data acquisition channels, sourcing channels or both.

Of course, not all DC modules will need isolation. For example, device power supply (DPS) in automated test equipment tends to draw the power from the system power supply, which has already been isolated.

Sourcing and Measuring: Most common application of photo ICs here is to isolate the analog circuits (input side) from the digital circuits (on processor side). Voltage transients from the input may generate soft errors on the digital side by creating wrong bits. Digital noise from the micro-processor's high speed signals may reduce the accuracy achievable on the analog side. In both of these cases, the optocoupler serves as an effective signal isolator by allowing separate grounds for analog and digital systems as shown in Figure 2. Another important point to note is that the analog components may be on 5V or higher, whereas the processor is usually at 3.3V, hence the optocoupler also serves as a level-shifter here.

Key considerations here will be the speed (propagation delay and data rate), supply voltage, noise immunity and size of the digital optocoupler.

Figure 2. Isolating Analog Front End from Digital Processor.



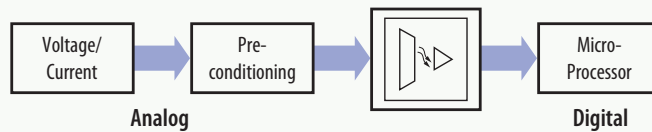
Part Number	Data Rate	Propagation Delay	Supply Voltage	Transient Immunity		Channel	Package
				CMR	V _{CM}		
ACSL-7210, ACPL-077L	25MBd	40ns	3.3V / 5V	20kV/μs	1000V	Bi-dir Dual / Single	S08
ACPL-772L	25MBd	40ns	3.3V / 5V	10kV/μs	1000V	Single	DIP8
ACPL-M75L/071L/W70L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-074L/K73L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Dual	S08/Stretched S08
ACPL-M61L/061L/W61L	10MBd	80ns	3.3V / 5V	20kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-064L/K64L	10MBd	80ns	3.3V / 5V	20kV/μs	1000V	Dual	S08/Stretched S08
ACSL-6xxx	10MBd	100ns	3.3V / 5V	10kV/μs	1000V	Multi-ch/Bi-dir	S08/S016
ACNT-H61L	10MBd	100ns	3.3V / 5V	20kV/μs	1000V	Single	14.2mm S08
ACFL-621xU*	10MBd	35ns	3.3V / 5V	20kV/μs	1000V	Dual/B-Dir	Stretched S012

* Denotes advance information at the time of print

The speed of the optocoupler must be able to handle the clock and data speeds for the analog-to-digital converter (ADC) and digital-to-analog converter (DAC). Dual supply voltage compatibility (3.3V and 5V) will enable level shifting and ease of design. Transient immunity helps to ensure effective signal isolation between the analog and digital circuitry. Our Stretched packages offer space savings and higher working insulation voltages and the ACSL series offer greater flexibility and integration with bi-directional and up to quad channel configurations.

Other integrated sensing solutions we offer are the ACPL-C79B/A/0 isolation amplifiers, and ACPL-C797/7970, isolated sigma-delta modulators. The isolation amplifiers sense the input signal and send it across the optical isolation barrier to the controller with gain. The sigma-delta modulators convert input signal to digital clock and data, which can be sent to controller directly (see Figure 3).

Figure 3. Sensing with Isolation Amplifier.



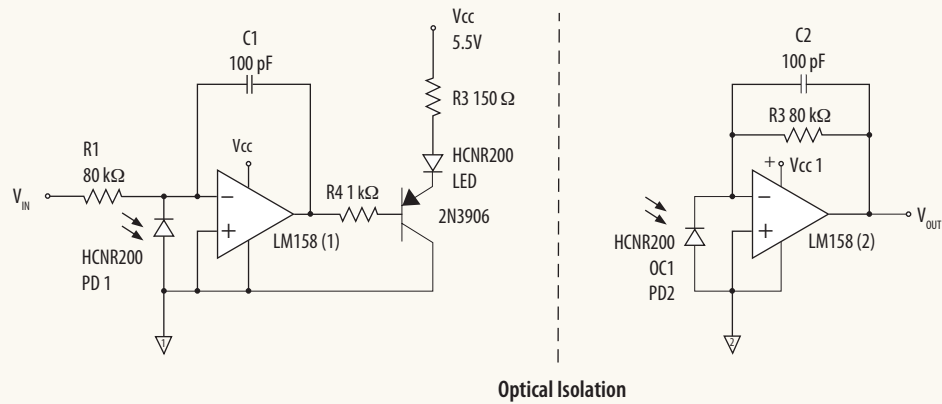
Part Number	Gain Tolerance	Non- Linearity	Output Configuration
ACPL-C79B	±0.5%	0.13%	Analog Differential
ACPL-C79A	±1%	0.13%	Analog Differential
ACPL-C797/7970	12 Bit ENOB	0.07%	Digital Sigma-Delta

The HCNR200/201 is commonly added in the DC modules to isolate analog signal in analog-front-end module or circuit. The HCNR200/201 is inserted between analog input and A/D converter chip to separates the analog input from the mixed signal ADC and digital circuits thoroughly; its galvanic isolation eliminates ground loop noise and any signal interference between analog and digital circuits grounding.

With flexible external circuits design, HCNR200/201 input DC or AC voltage can be up to 15V, and can transmit high precision voltage at low bandwidth (see Figure 4) or high speed analog signal up to 1.5 MHz. The HCNR200/201 consists of one LED and two closely matched photodiodes. The close matching of two photodiodes and special package design ensure stable gain K_3 (IPD_2/IPD_1) and excellent non-linearity.

Part Number	Package	Transfer Gain	Non-Linearity	CTR Range
HCNR201	Wide-body	$\leq \pm 5\%$	$\leq 0.05\%$	0.36 ~ 0.72%
HCNR200	Wide-body	$\leq \pm 15\%$	$\leq 0.25\%$	0.25 ~ 0.75%

Figure 4. Positive Polarity Input Voltage Analog Isolation Amplifier using the HCNR200 in Photo-Voltaic Mode.



AC Modules

AC modules refer to frequency and time domain-based modules. For bench-top equipment, common AC modules could be oscilloscopes, pulse and pattern generators (PPG), spectrum analyzers, bit-error rate (BER) tester, etc. In automated test equipment, common AC modules will be the PPG and timing measurement units. For data-acquisition systems, digitizers, oscilloscopes and PPG are available in PCI, PXI and VXI systems. It is common to see them divided into input devices (timing measurement units, oscilloscopes, digitizers, etc.) and output devices (pulse generators, pattern generators, etc.).

Similar to the DC modules, isolators are used to isolate the analog circuits (input side) from the digital circuits (on processor side) (see Figure 5). Voltage transients from the input may generate soft errors on the digital side by causing wrong bits. Digital noise from the micro-processor's high speed clock may reduce the accuracy achievable on the analog side. In both of these cases, the optocoupler serves as an effective signal isolator by separating the grounds of the analog and digital systems.

Key considerations here will be the speed (propagation delay and data rate) and size of the isolator.

Part Number	Data Rate	Propagation Delay	Supply Voltage	Transient Immunity		Channel	Package
				CMR	V _{CM}		
HCPL-0723/7723	50MBd	22ns	5V	10kV/μs	1000V	Single	S08/DIP8
ACSL-7210, ACPL-077L	25MBd	40ns	3.3V / 5V	20kV/μs	1000V	Bi-dir Dual / Single	S08
ACPL-772L	25MBd	40ns	3.3V / 5V	10kV/μs	1000V	Single	DIP8
ACPL-M75L/071L/W70L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-074L/K73L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Dual	S08/Stretched S08
ACML-7400/7410/7420	100MBd	36ns	3.3V / 5V	25kV/μs	1000V	Quad-ch/Bi-dir	S016 WB
HCPL-09xx/90xx	100MBd	20ns	3.3V / 5V	15kV/μs	1000V	Multi-ch/Bi-dir	S08/S016

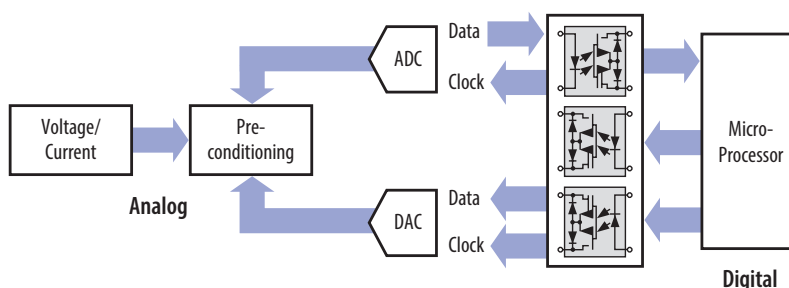
Benefits of Isolation

Further elaboration on the benefits of isolation highlighted in the previous 2 sections will be discussed here.

Common Mode (Transient) Immunity

When large voltage changes in the analog side occur at very high slew rates, common mode transients will result. In the absence of isolators, these transients will appear on the digital side. Even in the presence of isolators, the transient immunity of the isolator plays an important role to eliminate the interference to the digital side from the analog side.

Figure 5. Isolating Analog Front End from Digital Processor.



A good HVCMR value on the optocoupler provides good signal isolation against transients. Large voltage transients can be introduced on analog side, such as a -300V to +300V swing at the input of a multi-meter or oscilloscope, and this can create an error state in the digital bit stream after the ADC, resulting in an error bit to the processor as shown in Figure 6. The example below illustrates how missing bits on the digital side may occur when large voltage transients are introduced on the analog side.

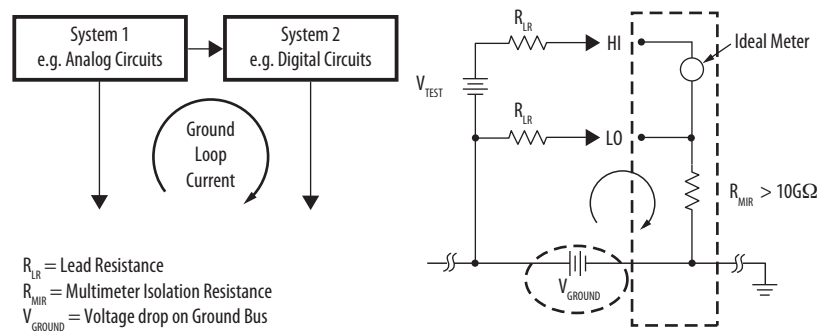
Figure 6. Missing Bit due to Poor Transient Immunity.



Ground Loops: Ground loops are common source of noise in measurement applications. It occurred when two connected terminals in a circuit are at different ground potentials, causing current to flow. This can cause significant error in the measurement. This is illustrated in Figure 7.

Using isolated hardware eliminates the path between signal source ground and the measurement device and prevents any current from flowing between multiple ground points. For example, a ground loop in multi-meters is like an unaccounted voltage source V_{GROUND} contributing to overall errors.

Figure 7. Analogy of Ground Loop Noise.



System Power Supply

For bench power supplies, these are usually stand-alone modules. These modules can be used in automated test equipment to supply power to a full rack of test cards or as part of the test equipment to supply power directly to the devices under test. In data-acquisition systems, there may be system power supply modules to supply power to the VXI, PXI or PCI cards.

Most system power supplies today either employ linear or switching type regulator. Depending on the system design, requirement and cost, each has its own advantages and disadvantages. The non-isolating type of converter is generally used where the voltage needs to be stepped up or down by a relatively small ratio, and there is no problem with the output and input having no dielectric isolation. However, non-isolated power supplies can be quite unsuitable for other applications where the output needs to be completely isolated from the input and the accuracy and responsiveness to the output demand is very critical in the test and measurement system. Here we present some topologies that may utilize optocouplers.

For lower cost and simple SMPS, the 1 MBd transistor output optocouplers are the most popular selections in the design for isolated feedback as shown in Figure 8.

Other than the standard 5-pin configuration, the ACPL-M51L* is also able to be configured in 4-pin with guaranteed AC and DC specifications.

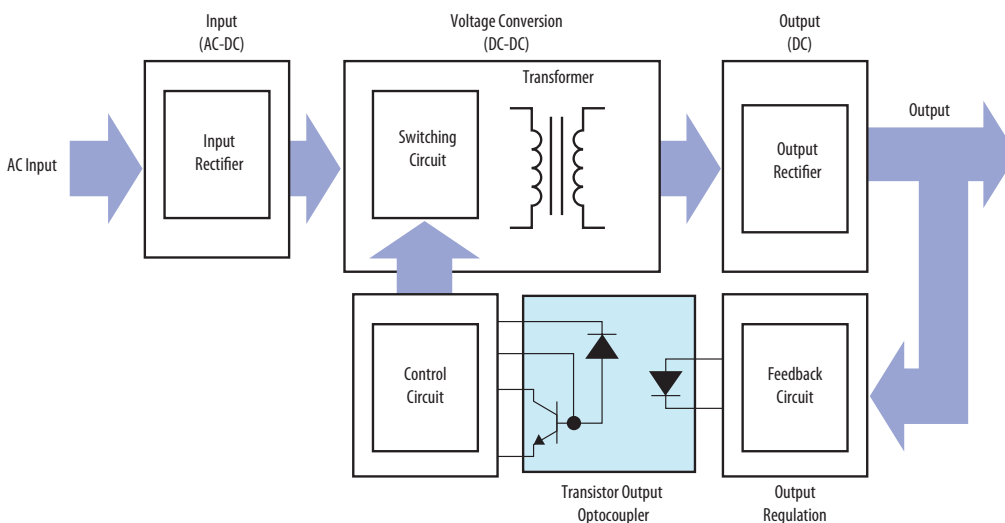
Key considerations will be space-savings with small packages. However, the minimum insulation voltage required to meet the safety regulatory standard will also be taken into consideration. Designers will also select the CTR range that is suitable for their needs.

Part Number	Package	Insulation Voltage	CTR Range
ACPL-M50L/M51L*	S05	3750	80 ~ 200%
ACPL-W50L	Stretched S06	5000	93 ~ 200%
HCPL-050L/0500/0501	S08	3750	7 ~ 50%
HCPL-250L/2502/2503	300 mil DIP8	3750/5000#	15 ~ 50%
HCNW135/136	400 mil DIP8	5000	5 ~ 50%

– with UL 5000VRMS/1 minute Option 020

* Denotes advance information at the time of print

Figure 8. Isolated Feedback with 1 MBd Transistor Output Optocoupler.



For higher precision error feedback, the CNR200 and CNR201 are used in the isolated feedback path as shown in Figure 9.

Part Number	Package	Transfer Gain	Non-Linearity	CTR Range
HCNR201	Wide-body	$\leq \pm 5\%$	$\leq 0.05\%$	0.36 ~ 0.72%
HCNR200	Wide-body	$\leq \pm 15\%$	$\leq 0.25\%$	0.25 ~ 0.75%

For other feedback path between primary and secondary circuits or to external circuits, low input-drive optocouplers such as the Darlington output are used.

Key considerations will be space-savings with small packages. However, the minimum insulation voltage required to meet the safety regulatory standard will also be taken into consideration. Designers will also select the CTR range that is suitable for their needs.

Part Number	Package	Channel	IF(ON) min.	CTR Range
HCPL-070A/4701	S08/DIP8	Single	0.04mA	800 ~ 25000%
HCPL-073A/4731	S08/DIP8	Dual	0.04mA	800 ~ 25000%
HCPL-M701/0701/ 6N139/HCNW139	S05/S08/DIP8/Wide-body	Single	0.5mA	400 ~ 5000%
HCPL-0731/2731	S08/DIP8	Dual	0.5mA	400 ~ 5000%
HCPL-M700/0700/ 6N138/HCNW138	S05/S08/DIP8/Wide-body	Single	0.5mA	300 ~ 2600%
HCPL-0730/2730	S08/DIP8	Dual	0.5mA	300 ~ 2600%

Figure 9. Isolated Feedback with High Linearity Analog Optocoupler.

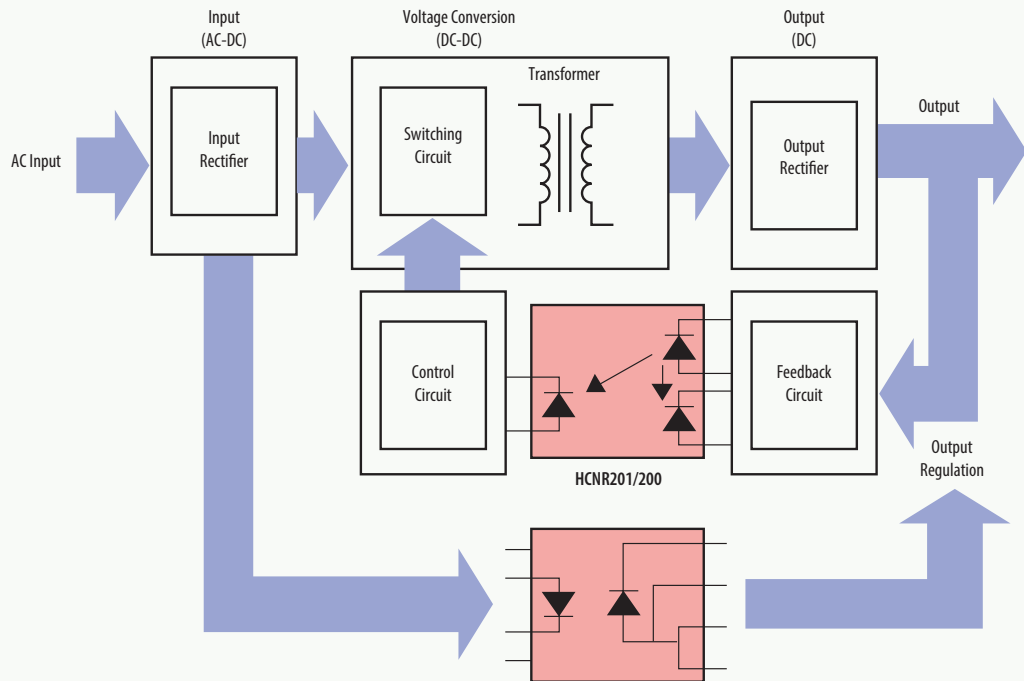
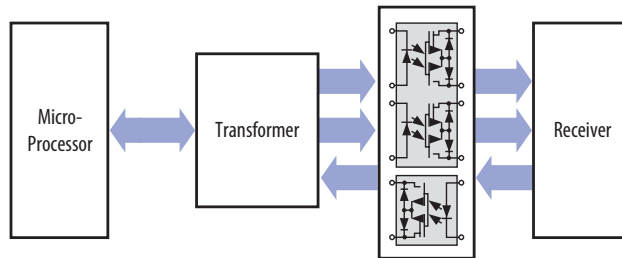


Figure 10. Digital Optocouplers for Communications.



Communications Module

Most test and measurement will have some form of communications module to be interfaced for control and monitoring of test processes, data collections and any feedback of fault detection. Remote monitoring and control provides real time access to the processes. Here, we digress to talk about safety insulation, as it becomes an important aspect where human interface comes in.

Safety Insulation

The most common safety standard used for test and measurement is the EN61010 or IEC-1010, which regulates the "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Usage."

This standard dictates the creepage, clearance and insulation levels required for isolation components based on the rated voltage of the equipment.

Insulation Category 2. Under this category, our DIP and stretch packages will be able to meet the 600V reinforced insulation requirements, while our SO parts are able to meet the 300V reinforced insulation requirements.

Insulation Category 4. Under this category, our 14.2mm stretched SO package of ACNT-Hxxx optocouplers are able to meet the 1000V rated line voltage basic insulation type with 12kV transient overvoltage capability. The ACNT-H61L is the 10MBd low power CMOS digital optocoupler. Applications for Category 4 include utility test equipment, monitoring and communication panels in smart meters / grid.

Communications Protocols

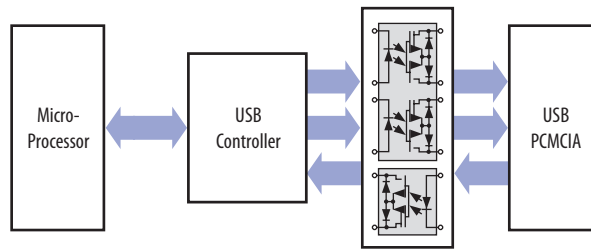
For bench top equipment, such as power supplies, oscilloscopes, multi-meters, the interface could be for personal computers (PC) control via GPIB, USB, serial or parallel ports. For data acquisition systems, such as PXI, PCI, and LXI systems, similar ports are present for interface to PC as well. For automated test equipment, additional interface for test handler control are present. Different interface will have different requirements.

General Purpose Interface Bus (GPIB), Serial Interface and Parallel Interface

Traditional RS232 serial and parallel interface have transmission speed of as low as 20 kbd, while others, like the RS422 and RS485, have maximum transmission rates of up to 35 Mbd.

The typical topology consists of the microprocessor communicating with the transceiver, which in turn, transmits through the optocoupler to the receiver illustrated in Figure 10.

Figure 11. Isolated USB with High Speed Optocouplers.



Part Number	Data Rate	Propagation Delay	Supply Voltage	Transient Immunity		Channel	Package
				CMR	V _{CM}		
HCPL-0300/2300	8MBd	160ns	5V	10kV/μs	1000V	Single	S08/DIP8
ACPL-M21L/021L/W21L	5MBd	250ns	3.3V/5V	25kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-024L/K24L	5MBd	250ns	3.3V/5V	25kV/μs	1000V	Dual	S08/Stretched S08
HCPL-0211/2212/HCNW2211	5MBd	300ns	5V	10kV/μs	1000V	Single	S08/DIP8/Wide-body
HCPL-2232	5MBd	300ns	5V	10kV/μs	1000V	Dual	DIP8
ACPL-M50L/W50L	1MBd	1000ns	3.3V/5V	15kV/μs	1500V	Single	S05/Stretched S06
ACPL-M51L*	1MBd	1000ns	2.5V/3.3V/5V	15kV/μs	1500V	Single	S05
ACPL-054L/K54L	1MBd	1000ns	3.3V/5V	15kV/μs	1500V	Dual	S08/Stretched S08
HCPL-M453/0453/4503/ HCNW4503/ACPL-K453	1MBd	1000ns	5V	15kV/μs	1000V	Single	S05/S08/DIP8/Wide-body/ Stretched S06
HCPL-0534/4534	1MBd	1000ns	5V	15kV/μs	1000V	Dual	S08/DIP8
ACFL-521xU*	1MBd	1000ns	5V	15kV/μs	1500V	Dual/ B-Dir	Stretched S012

* Denotes advance information at the time of print.

Universal Serial Bus

Universal Serial Bus (USB) is a device interface serial bus standard to allow plug-and-play capabilities. Avago optocouplers support both slow speed (1.5Mbd) and full-speed (12 Mbd) transmission mode for USB 1.0 illustrated in Figure 11.

The same key considerations for selection of the optocoupler apply here; speed, dual supply voltage compatibility, noise immunity and integration.

Part Number	Data Rate	Propagation Delay	Supply Voltage	Transient Immunity		Channel	Package
				CMR	V _{CM}		
ACSL-7210, ACPL-077L	25MBd	40ns	3.3V / 5V	20kV/μs	1000V	Bi-dir Dual / Single	S08
ACPL-772L	25MBd	40ns	3.3V / 5V	10kV/μs	1000V	Single	DIP8
ACPL-M75L/071L/W70L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-074L/K73L	15MBd	55ns	3.3V / 5V	10kV/μs	1000V	Dual	S08/Stretched S08
ACPL-M61L/061L/W61L	10MBd	80ns	3.3V / 5V	20kV/μs	1000V	Single	S05/S08/Stretched S06
ACPL-064L/K64L	10MBd	80ns	3.3V / 5V	20kV/μs	1000V	Dual	S08/Stretched S08
ACSL-6xxx	10MBd	100ns	3.3V / 5V	10kV/μs	1000V	Multi-ch/Bi-dir	S08/S016
ACFL-521xU*	1MBd	100ns	5V	15kV/μs	1500V	Dual/B-Dir	Stretched S012
ACFL-621xU*	10MBd	35ns	3.3V/5V	25kV/μs	10 00V	Dual/B-Dir	Stretched S012

* Denotes advance information at the time of print.

Isolation Products for Serial Communication



Avago Technologies Isolation Products Offer Solutions for I²C-SMBus (System Management Bus), PoE (Power Over Ethernet) and DAQ (Data Acquisition)

Inter-Integrated Circuit Control Bus

The Inter-Integrated Circuit (I²C) bus standard is a 20 year old control bus protocol developed by Philips Semiconductors. This proprietary industry control bus uses a simple bi-directional two wire concept, namely serial data (SDA) and serial clock (SCL) bus, for inter-IC control. Today, Philips has more than 400 I²C devices operating in three different frequencies at 100 KHz (Standard speed), 400 KHz (Fast speed) and 3.5 MHz (High Speed).

The importance of signal isolation during data transmission continues to be highly demanded in data communication buses. In addition to I²C bus, these data communication bus can include field bus and profibus. Other applications that require I²C isolation include System Management Bus (SMBus), Power Over Ethernet (PoE) and Data Acquisition (DAQ). When these data communication bus is exposed to noisy environment (generated from power supplies, common mode ground noises and loads), signal transient will occur which potentially leads to data integrity issue. Avago optocouplers can provide both signal isolation and voltage insulation caused by electrical shock. Further more Avago optocouplers are immune to Electromagnetic Interference (EMI) which can be initiated by radiated copper traces found in printed circuit boards (PCBs).

Some of the recommended optocouplers associating with Philips Buffer ICs that help to provide isolation in I²C short and extended communication are shown in Table 1.

Table 1. I²C short and extended communication recommended optocouplers.

Philips Buffer ICs	Recommended Avago Optocouplers
PCA9515 PB82B96 PB82B715	HCPL-060L; HCPL-260L ACPL-M62L; ACPL-W60L; ACPL-K63L ACPL-M61L, ACPL-061L, ACPL-064L, ACPL-W61L, ACPL-K64L ACPL-071L; ACPL-074L; ACPL-M75L ACSL-6210; ACSL-6310

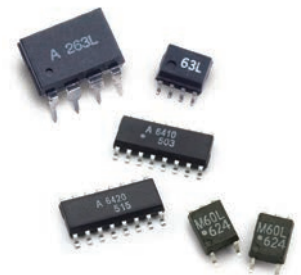
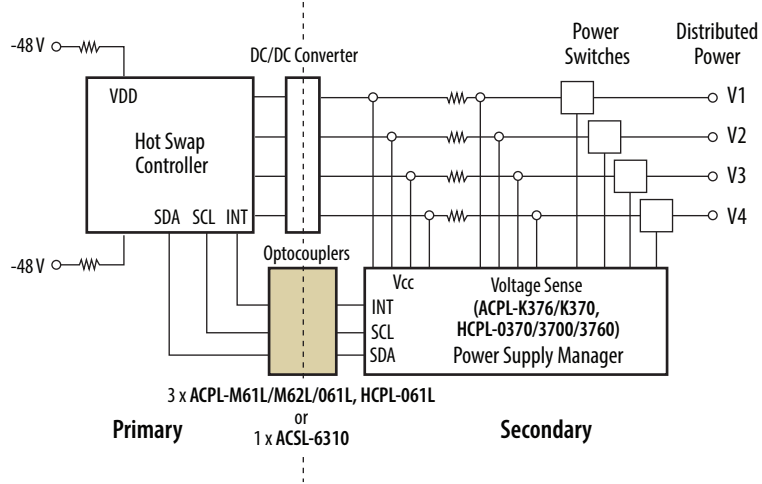


Figure1. SMBus power and control module.



Isolation at System Management Bus (SMBus)

In 1995, leveraging the I²C bus protocol, Intel defined a new system management bus (SMBus) standard which is found in Telecommunications and Ethernet infrastructures such as power and control module applications. During the I²C interface communication between the hot swap and microcontroller, optocouplers are used to isolate undesired signals and voltage surges (Figure 1 and Table 2).

Table 2. SMBus power system control recommended optocouplers.

Linear Tech. Controllers	Associated Avago Optocouplers
LTC4261CGN LTC4215UFD	HCPL-0300; HCPL-2300; HCPL-0630; ACPL-064L and ACPL-K63L ACSL-6210; ACSL-6310; ACSL-6410 and ACSL-6420

Avago Technologies today offers a wide range of interface photocouplers (less than 100 kBd to 50 MBd) and magnetic isolators (100 MBd speed). It is the first to offer multi-channels, bi-directional optocouplers to suit designs with multiple communication interfaces; helping to ease the design process through a reduction in system board space.

As shown in a typical SMBus power and control module in Figure 1, a designer can use 3 x 3.3 V/5 V low power digital ACPL-M62L/M61L Optocouplers or a single 15 MBd multi-channel, ACSL-6310 optocoupler to isolate transient signal noise from the Hot-Swap Controller and the Power Supply Manager.

In addition, The Avago ACPL-K370, HCPL-0370/3700 and ACPL-K376, HCPL-3760 Threshold-Sensing Optocouplers can be used to sense the AC/DC power on and off condition of the power supply buses. ACPL-K376/K370 comes in stretched SO8 packages that offered higher working voltage as compared to the DIP8 packages (HCPL-3700/3760). The devices utilize threshold sensing input buffer ICs which permit control of threshold levels over a wide range of input voltages with a single external resistor. The input buffer incorporates several features: hysteresis for extra noise immunity and switching immunity, a diode bridge for easy use with AC input signals, and internal clamping diodes to protect the buffer and LED from a wide range of overvoltage and over-current transients. Because threshold sensing is done prior to driving the LED, variations in optical coupling from the LED to the detector will have no effect on the threshold levels. See typical block diagram in Figure 2.

Figure 2. Typical block diagram.

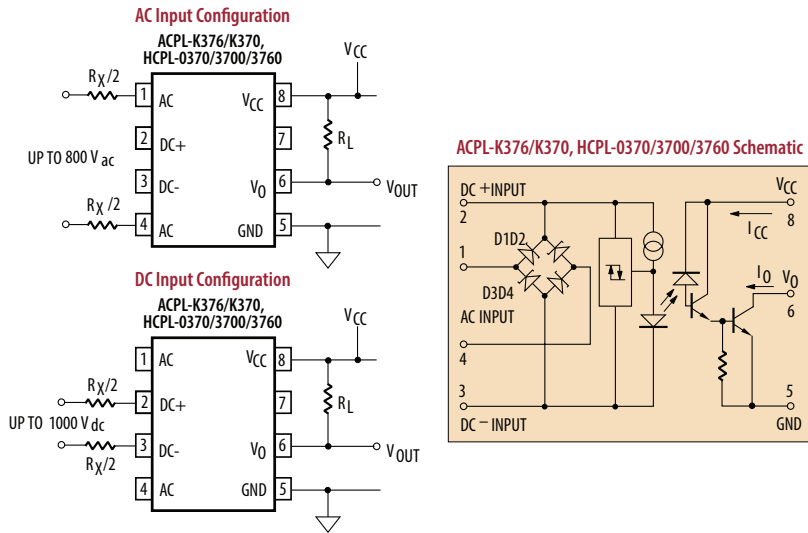


Figure 4. CAT5 cables with RJ45 connectors.

Power over Ethernet (PoE) Solutions

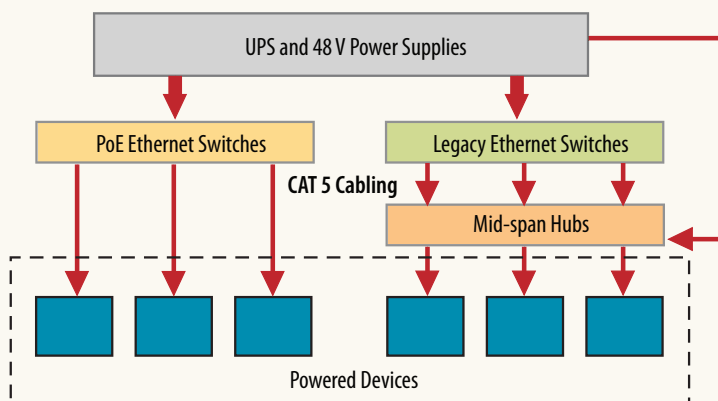
The IEEE 802.3af protocol for powering network devices via Ethernet cable is an emerging standard officially ratified by the IEEE in June 2003. Also known as Power over Ethernet (PoE), it specifies the transference of data and power (13 W, 48 V) over CAT5 copper wiring (local-area-network (LAN) cable) that is plugged into universal RJ45 connectors. Thanks to the growing demand for IP phones, wireless access points and industrial Ethernet, PoE has become increasingly popular. The IEEE 802.3af task force is even now evaluating higher power ratings that will soon be capable of powering desktop and notebook PCs, as well as other power-sensitive equipment, directly from a single LAN cable.

The basic architecture of the PoE physical layer is comprised of a 48 V power supply connected to an Uninterruptible Power Supply (UPS) which serves as backup power in the event of a power failure, and a direct connection to either Ethernet switches or a mid-span hub (Figure 3). Because existing Ethernet infrastructure does not have an embedded 48 V power supply, the mid-span hub serves as an interface between the 48 V power supplies and a non-PoE Ethernet switch box.

The PoE switches and mid-span hubs are connected to the Powered Devices (PD) through the existing CAT5 twisted-pair cables. Some of the more common PDs include web cameras security devices, Voice over Internet Protocol (VoIP) phones, and Wireless Access Points. All of the Ethernet ports are connected via universal RJ45 connectors (Figure 4).

In the industrial Ethernet market, the topology of the PoE implementation mimics that of the PoE network infrastructure with two exceptions - the PDs are industrial based, found in the device level, and the RJ45 connectors are much more robust. In this market, some of the more common PDs are industrial sensors and programmable, temperature and actuator controllers.

Figure 3. PoE overview block diagram.



Isolation Product Solutions

Avago Technologies' Isolation Product Division (IPD) provides optocoupler solutions for Power Source Equipment (PSE) and PDs. In the PSE application, two HCPL-063L 3.3 V, 15 MBd, dual channel optocouplers can be used to provide isolation on the I²C address bus from the 48 V power supply lines (Figure 5). Alternatively, a single multi-channel optocoupler, such as ACSL-6420 which offers 4 channels with 2 bi-directional channels or ACSL-6310 which offers 3 channels with 1 bi-directional channel, can be used to achieve significant space savings and ease of design (Figure 5, Figure 6 and Table 3).

To date, there are many PoE controllers which have effectively utilized Avago optocouplers. Some of the recommended parts are shown in Table 4.

Table 3. Multi-Channel Bi-Directional Digital Optocoupler Product Selection.

Device	Part No.	Package	PWD ns Max.	CMR - V/μs@V _{CM}		V _{ISO} V _{RMS} Min.	V _{IORM} V peak
				CMR V/μs (Min.)	V _{CM} V		
Dual, Bi-Directional	ACSL-6210-00RE	S08	35	10000	1000	2500	560
Triple, All-in-One	ACSL-6300-00TE	S016	35	10000	1000	2500	560
Triple, Bi-Directional, 2/1	ACSL-6310-00TE	S016	35	10000	1000	2500	560
Quad, All-in-One	ACSL-6400-00TE	S016	35	10000	1000	2500	560
Quad, Bi-Directional, 3/1	ACSL-6410-00TE	S016	35	10000	1000	2500	560
Quad, Bi-Directional, 2/2	ACSL-6420-00TE	S016	35	10000	1000	2500	560

Notes: * AC Specifications are based on V_{DD} = 5 V

Table 4. PSE controllers with recommended Avago's optocouplers.

PSE Controllers	Recommended Avago Optocouplers
Linear Technologies LTC4258 LTC4259A	ACNT-H61L HCPL-060L; HCPL-063L; ACPL-W60L; ACPL-K63L; ACPL-M62L ACPL-071L; ACPL-074L; ACPL-M75L
PowerDsine PD64004A PD64012	ACSL-6210; ACSL-6420; ACSL-6310 HCPL-050L; HCPL-053L; HCPL-250L; HCPL-253L; HCPL-0501; HCPL-0531; HCPL-2502; HCPL-2531 ACPL-M61L; ACPL-061L; ACPL-064L; ACPL-W61L; ACPL-K64L ACPL-M50L; ACPL-054L; ACPL-W50L; ACPL-K54L
Maxim MAX5913 MAX5914 MAX5922	
Texas Instrument TPS2383	

Figure 5. PSE block diagram.

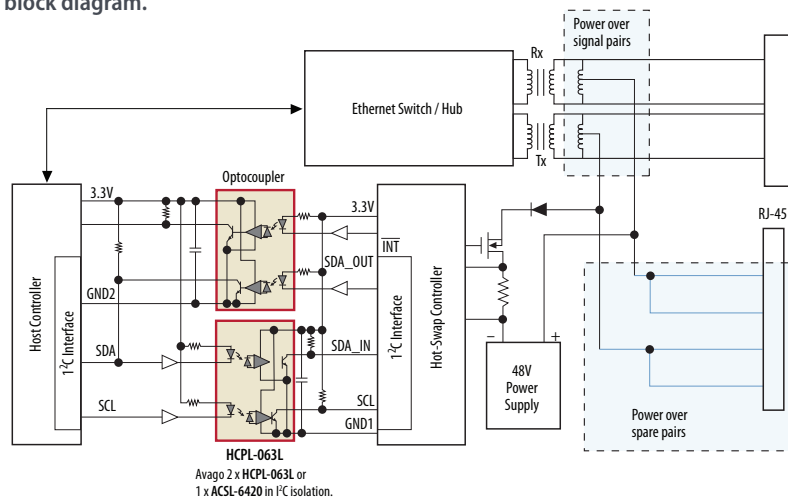


Figure 6. I²C with no interrupt address line.

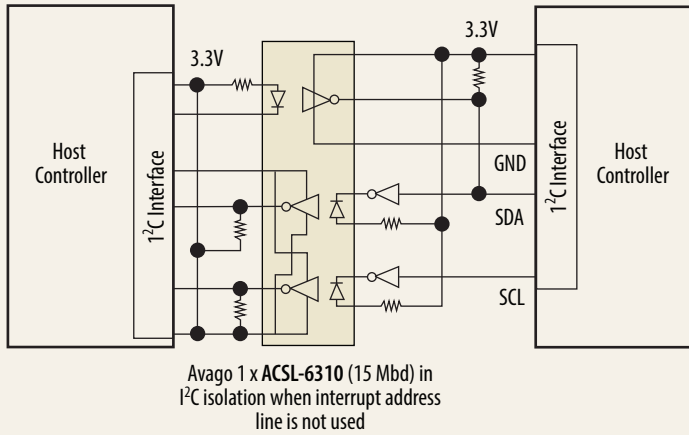
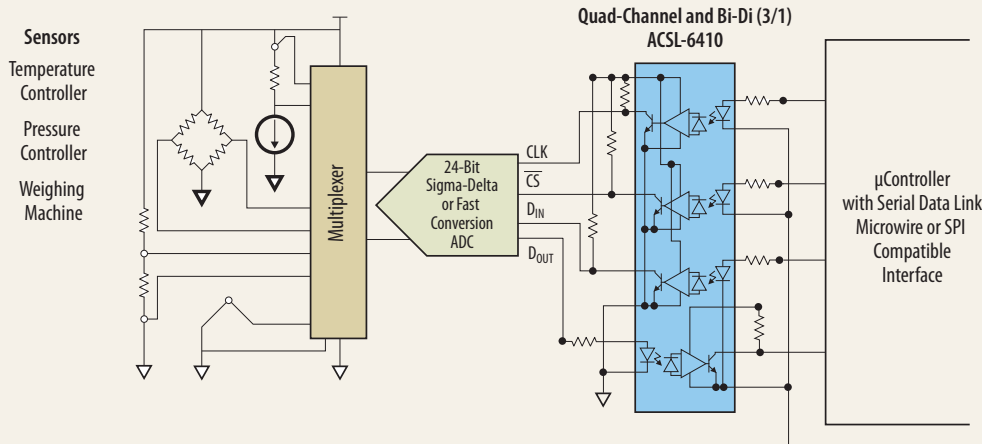


Figure 7. ADC or DAC block diagram.



Isolation in a Data Acquisition System

In a typical data acquisition system, isolation helps to ensure data integrity between the ADC and the microcontroller. As shown in Figure 7, the three forward channels with one reverse channel optocoupler, ACSL-6410, can provide this isolation. As I²C comes with different switching speed, the other recommended optocouplers are found at Table 5.

Table 5. ADC or DAC recommended Avago's optocouplers.

Part Number	Speed		
	Standard	Fast	High Speed
	100 kHz	400 kHz	3.4 MHz
	1 MBd	15 MBd	25 MBd
Avago Technologies Product Offerings	ACPL-M50L/054L ACPL-W50L/K54L	ACPL-074L ACPL-064L ACSL-6xxx	ACSL-7210, ACPL-077L

Avago Technologies' Isolation Product Solutions for Power Generation Applications



Alternative Power Generation is an emerging trend in renewable energy nowadays, driven by a market in which gasoline demand outstrips the supply from the producers and drives up prices. This move is motivated, in part, by the readily abundant availability of renewable energy sources in the environment, as well as their low running cost and their ability to self-regenerate. As a result, natural resources like solar and wind are now being converted to generate alternative sources for use in commercial and industrial markets (Figure 1 and 2).

Inverters, chargers and converters play a crucial role in enabling this conversion process. But, as the demand for their use in power-generation applications increases, high-frequency noises from switching devices and the power surges from instantaneous glitches in the systems will adversely affect the power supply quality. Optocouplers offer an effective means of protection by providing isolation from unwanted signals, as well as insulation from high-voltage glitches in the power converters.

As a worldwide market leader in optical isolation devices, Avago Technologies develops optocouplers that are specifically designed and manufactured to meet the stringent requirements in power-generation system applications. Featuring high CMR performance, high maximum insulation voltage and a wide operating temperature, Avago Technologies broad range of isolation products are flexible enough for power-generation system designs in both commercial and industrial applications. They are fully compliant with worldwide regulatory standards, including IEC (International Electrotechnical Commission), UL (Underwrites Laboratories, Inc.), CSA (Canadian Standard Association) and EN (European Union) approvals.

Figure 1. Wind-Power Generation Block Diagram.

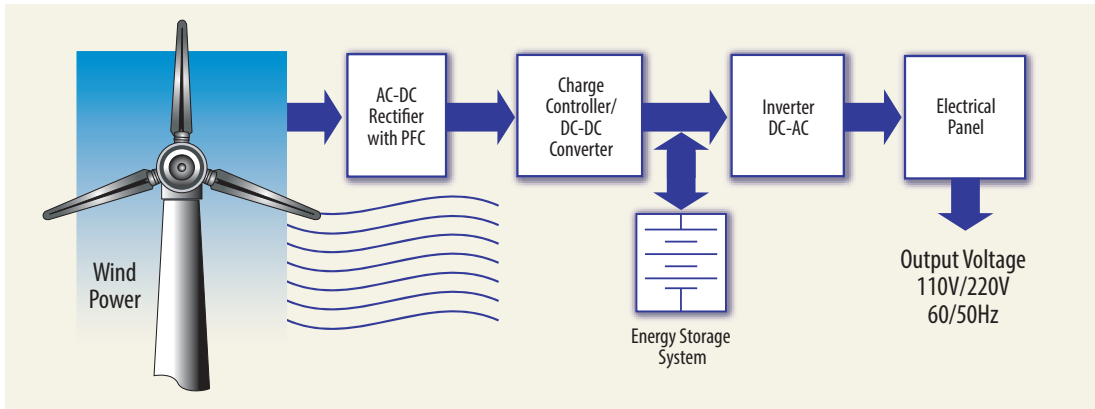
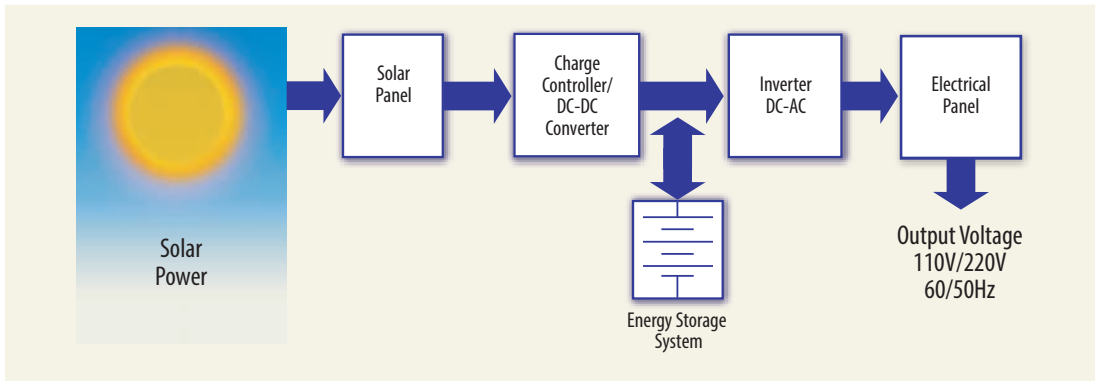


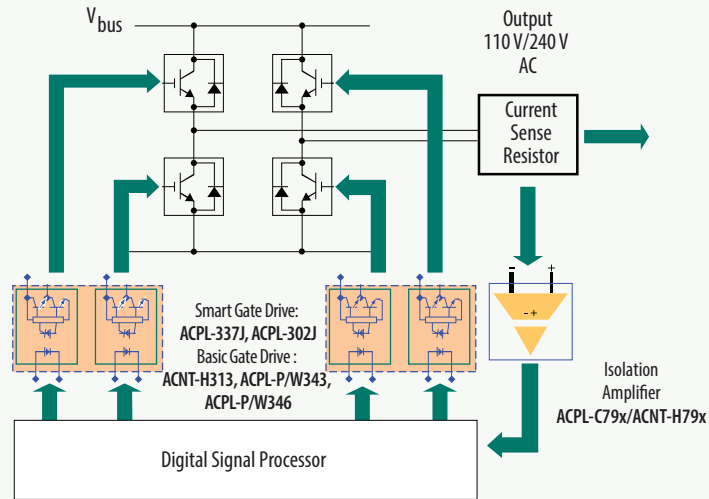
Figure 2. Solar Power Generation Block Diagram.



Key applications for isolation and insulation solutions in power-generation system components include:

- Inverters (single/three-phase)
- Charge controllers (DC-DC converters)
- Communications (for system controls and monitoring)

Figure 3. Single-Phase Inverter System with Gate-Drive Optocoupler and DSP.



Inverter Systems

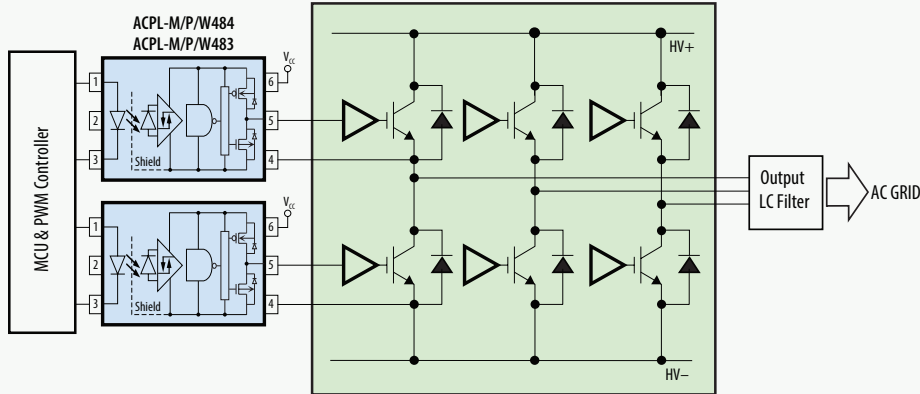
The inverter is the intelligent block of a renewable energy system. It seamlessly converts DC power to clean and reliable AC electricity. Inverters can be either single (commercial) or three-phase (industrial) discrete components or modules and are controlled by a DSP or microcontroller to provide high-efficiency switching control (Figure 3). High-performance inverter systems require precision timing control of power devices as well as isolation.

IGBT/MOSFET Gate Drive

IGBT/MOSFET power devices convert DC-to-AC voltages and currents in the power inverter stages to drive electrical devices operating at 110 and 240 V. Avago's gate drive optocoupler portfolio has a maximum output current ranging from 0.4A up to 5A, high CMR rating up to 50kV/ μ s and IGBT protection features. Avago's gate drive optocouplers, such as the ACPL-33xJ, ACNT-H313 and ACPL-P/W34x, provide isolation for direct drive power devices, and isolate low voltage control system's MCU/PWM controllers from high voltage power devices (see Figure 3).

The ACPL-337J device features a 4A rail-to-rail output while the ACPL-302J is an integrated flyback controller for DC-DC converters. Both are "smart" gate drivers with an active Miller clamp, IGBT DESAT detection, and Under Voltage Lock-Out (ULVO) with feedback providing a complete fail-safe cost-effective gate drive solution. The ACNT-H313 features the industry's highest rated peak working voltage (VIORM) of 2,262 V in a compact 14.2mm stretched SO8 package, enabling high voltage insulation and protection in space-constrained applications. The ACNT-H313 is ideal for use in high-voltage applications such as the centralized renewable energy inverters. The ACPL-P/W343(4A) and ACPL-P/W346(2.5A) are basic gate drivers targeting specifically for IGBT and MOSFET drive respectively. The ACPL-P/W346 has the fastest maximum propagations delay of 120ns suitable for high frequency operation.

Figure 4. Typical IPM Optocoupler Inverter Interface.



Intelligent Power Module (IPM) Interface Optocoupler

Avago Technologies has developed a series of IPM interface optocouplers, ranging from 1 to 10 MBd (Figure 4). Its most recent offering, the ACPL-P484/483, is the fastest 10 MBd IPM Optocoupler on the market with a HVCMR of 30 kV/ μ s at 1 kV-V_{cm} and a propagation delay of 120 ns, maximum. This module has a built-in Schmitt trigger that provides logic-compatible waveforms which eliminate the need for additional wave shaping, and a totem pole output which eliminates the need for a pull-up resistor and a positive input/output logic inverter. With these features, a direct drive IPM or gate-drive application from a high-output current of up to 125 mA is viable. Avago Technologies IPM Optocouplers also feature a transistor output driving capability.

Charge Controller (DC-DC Converter)

The charge controller (DC-DC converter) is the mainstream component of the solar power system. It converts the solar energy in DC voltages into a higher or lower potential, depending on the load as well as the battery system. Typical DC-DC converter topologies are half-/full-bridge type (Figure 5). Depending on the system requirement, each will deliver different output requirements. To achieve higher efficiency of the DC-DC converter, a high switching frequency converter is used. In high-frequency switching, noise is an issue and requires some form of isolation. Proper grounding is also needed to eliminate leakage current that will affect the stability of the electrical system. For these applications, Avago Technologies selection of gate-drive optocouplers are available in different output drive currents ranging from 0.4 to 5 A.

Figure 5. Typical Single-Phase Dual Active Full-Bridge DC-DC Converter.

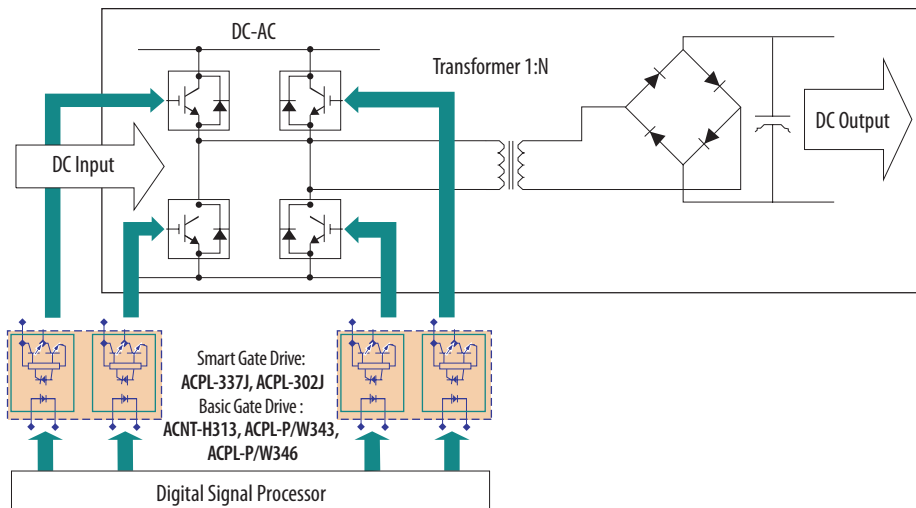
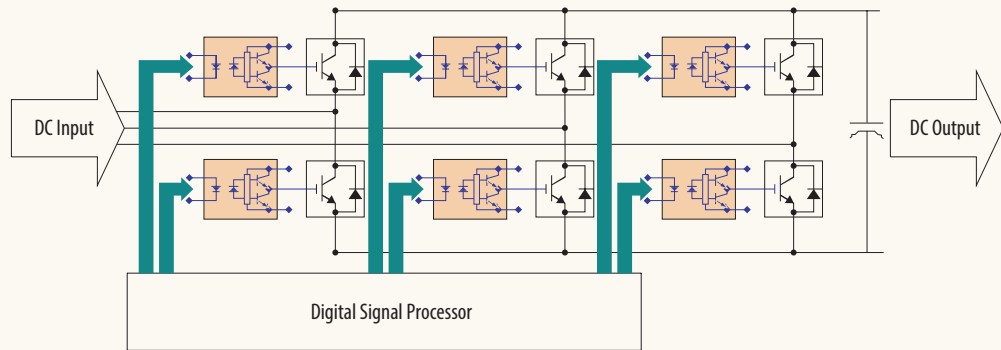


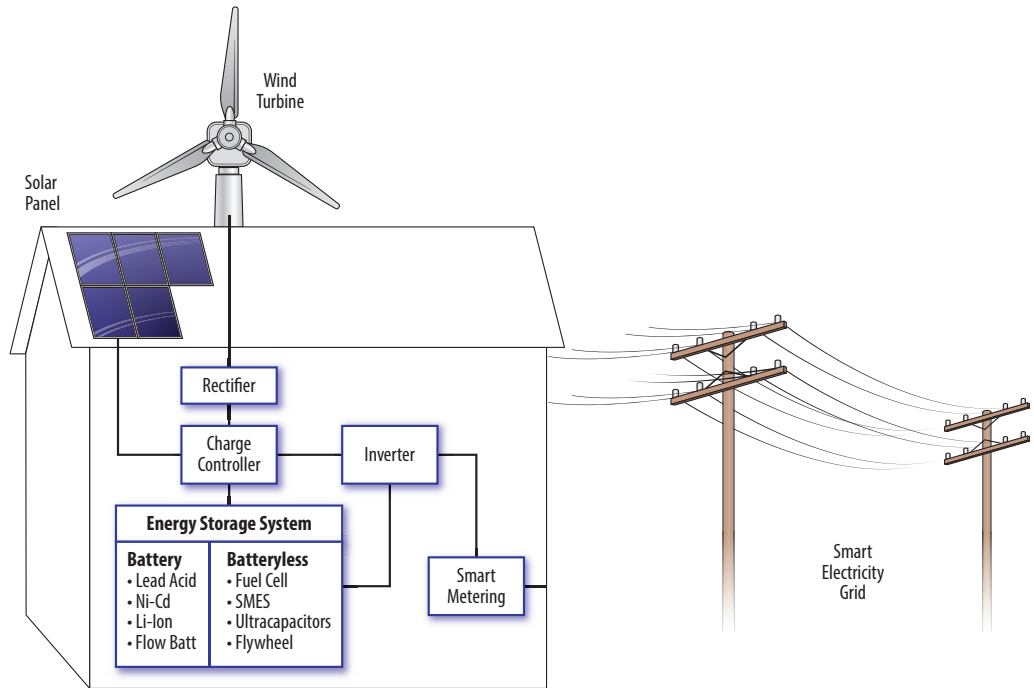
Figure 6. AC-DC Rectification with Gate-Drive Optocouplers for discrete control in high-powered systems.



Rectifier/Charge Controller (AC-DC Converter)

The rectifier/charge controller (AC-DC controller) is the front-end of the wind-power system that transforms AC power to DC by means of rectification. Typical AC-DC rectifier/converter topologies are half-/full-bridge/three-phase, together with power factor correction circuitry. Typical rectification components use controlled switches such as Thyristors, IGBTs or MOSFETs. Since high voltage is present in the switching between the microcontroller, isolation is required. For this application, Avago Technologies selection of gate-drive optocouplers are available in different maximum output drive currents ranging from 0.4 to 5A, as well as different switching speeds (Figure 6).

Figure 7. Energy Storage System.



Energy Storage System

Renewable energy such as solar power and wind power fluctuates according to weather. Energy Storage System saves power from renewable energy sources when it is sunny or windy, and used stored power in storage system when it is cloudy or windless. Or it stores electricity when the demand is low and uses the stored electricity when the demand is high. This improves energy efficiency and stabilizes operations of the electricity grid.

With the implementation of smart grid that optimizes power system efficiency by convolution of conventional power grid system and IT technology. Smart metering with bi-directional communication and distributed computing system is needed. Since the metering of the power signal occurs between the low voltage systems, isolation is required to eliminate interference and transient instances. Avago Technologies has a wide range of interface optocouplers with speed ranging from 100 kBd to 10 MBd, High-speed CMOS optocouplers range from 12.5 MBd to 50 MBd and up to 100 MBd for digital isolators. In addition, Avago Technologies is the first in the industry to offer multichannel, bidirectional optocouplers to suit designs with multiple communication interfaces that help reduce system board space and increase higher integration. Avago offers dual channel bidirectional direct LED drive in the 1 MBd and 10 MBd versions and buffered CMOS drive in the 25 MBd version.

Figure 8. Battery and System power monitoring

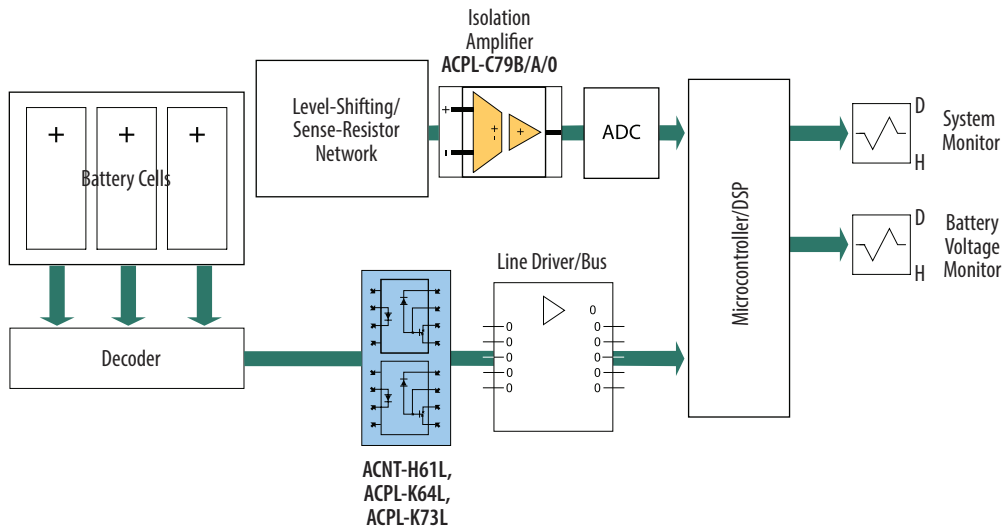
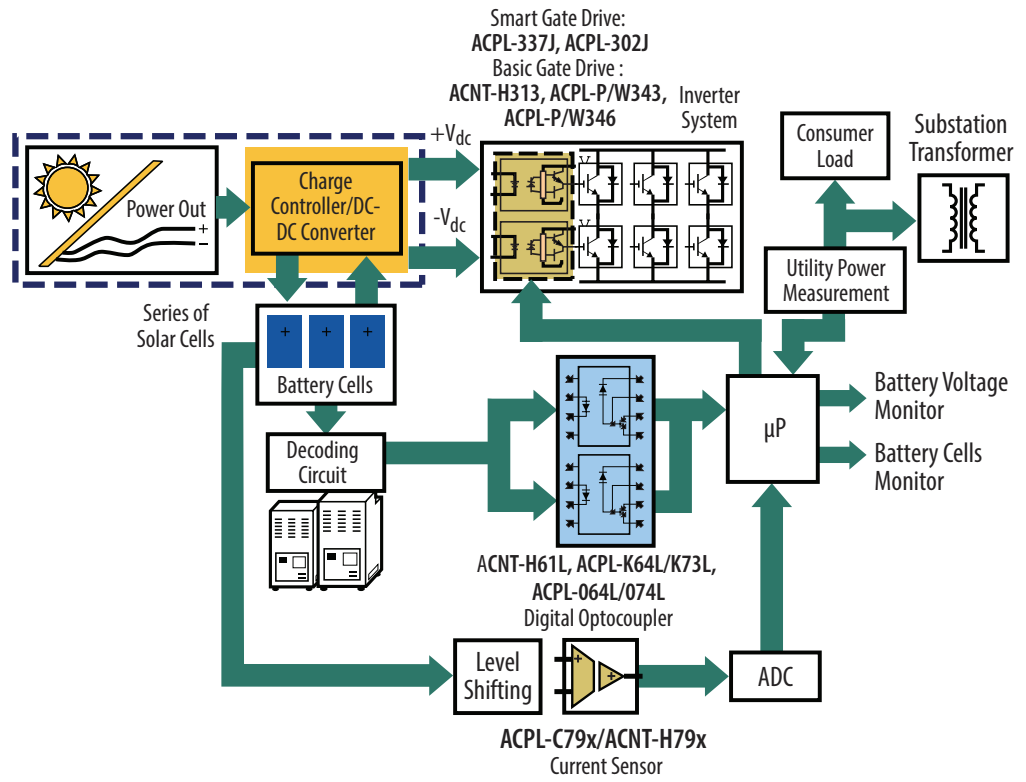


Figure 9. Typical Solar Power system block diagram



Avago Optocouplers in Intrinsic Safety Applications



The IECEx is a certification system which verifies compliance with IEC international standards relating to equipment for use in explosive atmospheres. The safety requirement for equipment under IECEx is based on the description in the international standards IEC 60079 series (Table 1). IEC 60079-11 specifies the construction and testing of intrinsically safe apparatus intended for use in an explosive atmosphere and for associated apparatus, which is intended for connection to intrinsically safe circuits which enter such atmospheres.

Table 1. Type of IEC 60079-x standards

Number	Title	Number	Title
60079-0	General requirements	60079-7	Increased safety 'e'
60079-1	Flameproof enclosures 'd'	60079-11	Intrinsic safety 'i'
60079-2	Pressurized enclosures 'p'	60079-13	Pressurized room 'p'
60079-5	Powder filling 'q'	60079-15	Type of protection 'n'
60079-6	Oil immersion 'o'	60079-18	Encapsulation "m"

Table 2. IEC 60079-11 General Safety Requirements of clearance, creepage distances and separations

1	2		3		4		5	
Voltage (pk) V	Clearance mm		Separation distance through casting compound mm		Separation distance through solid insulation mm		Creepage mm	
Level of protection	ia, ib	ic	ia, ib	ic	ia, ib	ic	ia, ib	ic
10	1.5	0.4	0.5	0.2	0.5	0.2	1.5	1.0
30	2.0	0.8	0.7	0.2	0.5	0.2	2.0	1.3
60	3.0	0.8	1.0	0.3	0.5	0.3	3.0	1.9
90	4.0	0.8	1.3	0.3	0.7	0.3	4.0	2.1
375	6.0	2.5	2.0	0.6	1.0	0.6	10.0	4.0

ia : Very high ignition protection level; application for zones 0, 1, 2

ib : High ignition protection level; application for zones 1, 2

ic : Improved ignition protection level; application for zone 2

Zones 0, 1, 2 refer to the gas zone classification. Zone 0 is classified as explosive atmosphere exists always, frequently or long term. Zone 1 is classified as occurs occasionally in normal operation. Zone 3 is classified as normally does not occur in normal operation or only for short times

IEC 60079-11 Intrinsic Safety

The basic principle of IEC 60079-11 to achieve intrinsic safety is for the energy in the power circuit to be limited preventing unusually high temperatures, ignition sparks or electric arcs that can create ignition energy, required to cause an explosion. To limit the energy (power), a fuse or resistor in a series (current limiting) and a zener diode in parallel (voltage limiting) should be implemented.

IEC 60079-11 requires separation of conductive parts between intrinsically safe and non-intrinsically safe circuits. From Table 2 IEC 60079-11, General Safety Requirements including clearance, creepage distances and separations, there are different requirements of separation distance through insulation structures. The casting compound in column 3 refers to compounds such as epoxy resin while examples of solid insulation in column 4 are polyester film and silicone. Avago optocouplers include internal clearance, or distance through insulation (DTI), as part of the insulation and safety related specifications. Using optical technology for galvanic isolation, the DTI forms the straight-line distance thickness between the LED emitter and the detector within the optocoupler. The optocoupler's DTI is able to meet the separation distance requirements of gas zone classification 0 to 2, depending on voltage level of protection.

Avago Optocouplers Meet Intrinsic Safety Criteria

While Avago optocouplers meet the stringent separation distance requirements, alternative technology isolators are not able to achieve this with their structural DTI at less than 20m. The 13 mm creepage/clearance ACNV optocouplers family, the 10 mm widebody optocouplers, and the 8 mm ACPL-Cxxx optocouplers, have insulation material classified as a casting compound. This allows ACNV optocouplers to meet up to 375V (ia, ib) level of protection and ACNW/HCNW optocouplers up to 60V (ia, ib) level of protection (Table 3).

Table 3: Avago optocouplers of clearance, creepage distances and separations

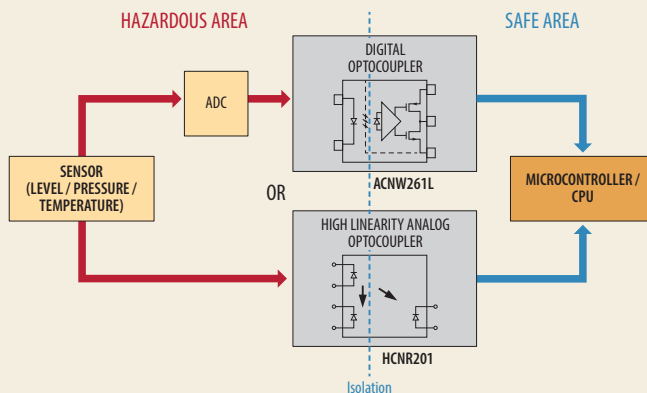
Optocoupler Prefix Number	ACNV	ACNW / HCNW / HCNR	ACNT-Hxxx	ACPL-Cxxx
DTI (mm)	2	1	0.5	0.5
Creepage (mm)	13	10	14.2	8
Clearance (mm)	13	9.6	14.2	8
Level of protection	375V (ia, ib), 1300V (ic)	60V (ia, ib), 750V (ic)	60V (ia, ib), 90V (ic)	10V (ia, ib), 90V (ic)

Applications

Optocouplers are used in intrinsic safety applications such as meters and field transmitters that require level, pressure, and temperature measurement. Optocouplers meet the safety requirements and provide reinforced insulation between field sensors and micro controllers of the control board. Figure 1 block diagram illustrates this.

An application example of optocouplers used in equipment with a work environment of an explosive atmosphere are fluid pumps in sewage and petrol stations. The widebody of the Avago 10 MBd low power ACNW261L is used as an isolated serial communication in the control board for sewage flow meters. The optocoupler's DTI of 1 mm is critical as waste in the sewers moves constantly and this exposes the fluid pump to the explosive methane gas. Avago optocouplers, with its unique strength of a thick internal clearance, or distance through insulation, are able to meet the separation distance requirements defined by IEC 60079-11 in intrinsic safety applications as required by IECEx

Figure 1. Isolation in a Field Transmitter (Flow / Level / Pressure / Temperature).





Your Imagination. Our Innovation

Avago Technologies is a leading designer, developer and global supplier of a broad range of analog, digital, mixed signal and optoelectronics components and subsystems with a focus in III-V compound semiconductor design and processing. Backed by an extensive portfolio of intellectual property, Avago products serve four primary target markets: wireless communications, wired infrastructure, enterprise storage, and industrial and other. Avago has a global employee presence and rich heritage of technical innovation spanning over six decades.

Avago has strong market positions across a broad range of market segments with highly differentiated products that include:

- Film Bulk Acoustic Resonator (FBAR) Filters
- RF Front End Modules
- Parallel Optics Transceivers
- High Speed SerDes ASIC
- HDD Read Channel & Preamplifiers
- RAID and SAS I/O Controllers
- PCIe Switches
- Optocouplers
- Motion Encoders
- Industrial Fiber Solutions
- LED Display & Signage Solutions



For product information and a complete list of distributors, please visit our website:

www.avagotech.com

www.avagotech.com/optocouplers

Avago, Avago Technologies, and the A logo are trademarks of Avago Technologies in the United States and other countries.
Data subject to change. Copyright © 2014-2015 Avago Technologies
AV00-0144EN 3/25/15

Avago
TECHNOLOGIES