HEWLETT PACKARD

Designer's Guide to Isolation Circuits

About This Designer's Guide

Hewlett-Packard optocouplers can be used in an array of isolation applications ranging from power supply and motor control circuits to data communication and digital logic interface circuits.

To help you choose and design with Hewlett-Packard isolation components, this Designer's Guide contains 50 popular application circuits and recommended HP optocouplers.

This handbook begins with a selection guide followed by sections discussing critical optocoupler design parameters such as Insulation and Withstand Voltage, Regulatory Agency Safety Standards, Common-Mode Transient Rejection, Product Life and light emitting diode (LED) aging. The rest of the guide consists of application circuits.

Each application circuit is accompanied by:

1. A brief description.
2. Highlights of circuit performance.
3. Circuit benefits.
4. References for additional technical information.
5. A list of alternative HP parts indicating comparably performing products available in varying package styles for maximum design flexibility.

How to Use This Guide

Several indexes are included to help locate applications and products.

- The table of contents lists the 50 applications by their general description.
- An alphanumeric index lists all applications by title.
- Selection Guides in the form of tables contain basic product specifications which allows you to quickly select the products most suitable for your applications.

Most data sheets for products recommended here can be found in Hewlett Packard's Optoelectronic Designer's Catalog, or they may be ordered from your local HP representative.

How to Order

To order any component in this guide or additional applications information, call the HP office nearest you and ask for a Components representative.

Although product information and illustrations in this guide were current at the time it was approved for printing, Hewlett-Packard, in a continuing effort to offer excellent products at a fair value, reserves the right to change specifications, designs, and models without notice.

Table of Contents

Optocoupler Selection Guide

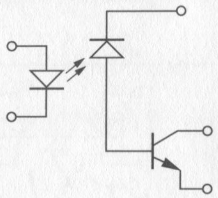
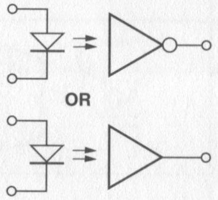
Hewlett-Packard offers a broad range of isolation products which provide performance features and benefits that are unmatched in the industry. Some of the leading product performance technologies that Hewlett-Packard offers include:

- Dielectric Withstand Voltage Rating as high as 5000 Vac/1 min (per UL)
- Worldwide Safety Approvals, including the highest Maximum Working Insulation Voltage (V_{IORM}) at 1000 V (per VDE)
- Common-Mode Transient Noise Immunity as high as 15 kV/µs (Minimum)
- A wide variety of surface mount and multi-channel packages, including the highest density optocouplers in the world.
- Lowest power dissipation optocouplers available, with input currents as low as 40 µA
- Highest speed optocouplers, with data rates as high as 50 MBd and propagation delays as low as 50 ns
- Wide operating temperature ranges for industrial and military environments
- A full line of hermetically-sealed optocouplers for military and space applications

Table 1. Optocoupler Application Selection Guide

Equipment/Circuit Application	Optocoupler Product Family				
	Power Transistor Interface	Isolation Amplifier and Analog	Digital Interface	Application-Specific	Solid-State Relays
Aerospace/Commercial Aircraft	●	●	●	●	●
Consumer Electronics	●	●	●		
Datacommunications		●	●	●	
Flat-Panel Displays	●		●		
Industrial Switching					●
Input/Output Interface		●	●	●	
Military/High-Reliability	●	●	●	●	●
Motor Control and Inverters					
Gate/Base Drive	●				
Voltage Sensing		●			
Current Sensing		●			
Fault Detection			●		
Medical Equipment	●	●	●		●
Power Supply	●	●	●	●	
Telecommunications			●		●
Test and Measurement		●	●		●
Video Interface		●			

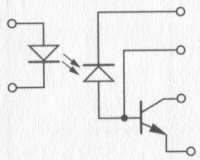
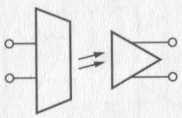
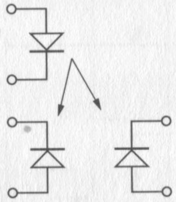
Table 2. Power Transistor Interface Optocouplers

Device	Minimum CMTR		Max. $t_{PROP.}$	V_{CC} Range	Peak I_O	8-pin DIP and Gull-Wing Surface Mount Option 300		Small-Outline SO-8		Extra Insulation Wide-Body Package	Hermetic/ MIL-H-38534 Package
	dV/dt (V/µs)	V_{CM} (V)	(µs)	(V)	(A)	Single Channel Package	Dual Channel Package	Single Channel Package	Dual Channel Package		
	15,000	1500	1	1.5-30	0.008	HCPL-4503	HCPL-4534	HCPL-0453	HCPL-0534	HCNW4503	
	15,000	1500	0.5	1.5-30	0.008	HCPL-4504		HCPL-0454		HCNW4504	
	15,000	1500	0.37	4.5-30	0.015	HCPL-4506		HCPL-0466		HCNW4506	
	1000	50	0.3	4.5-20	0.015	HCPL-2200 HCPL-2219[4]					HCPL-52XX HCPL-62XX
	10,000	1000	0.3	4.5-20	0.025	HCPL-2211 HCPL-2212	HCPL-2232	HCPL-0211		HCNW2211	
	10,000	1000	0.1	4.5-5.5	0.050	HCPL-2611	HCPL-4661	HCPL-0611	HCPL-0631	HCNW2611	
	1,500	600	5	5.4-18	2	HCPL-3000					
	1,500	600	0.5	15-30	0.4	HCPL-3100 HCPL-3101					
	15,000	1500	0.6	15-30	2.0	HCPL-3120					

Notes:

1. All above optocouplers are UL1577 (V_{ISO} = 2500 V rms/1 min) and CSA approved, except HCPL-3000, -3100 and -3101.
2. HCNW4503/4/6 and HCNW2211/2611 optocouplers are VDE 0884 approved (V_{IORM} = 1000 V rms).
3. Contact your HP representative for availability of Option 060 (VDE 0884, V_{IORM} = 300 V rms), and Option 020 (UL1577, V_{ISO} = 5000 V rms/1 min).
4. HCPL-2219 has a minimum CMTR of 2500 V/µs (V_{CM} = 400 V).

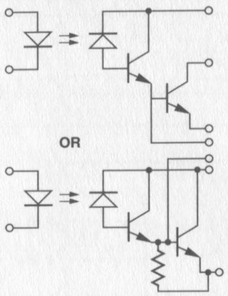
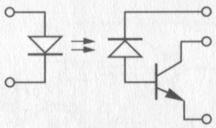
Table 3. Isolation Amplifier and Analog Optocouplers

Device	Typical Bandwidth	Typical Non-Linearity	Typical Isolation Mode Rejection Ratio IMRR	8-pin DIP and Gull-Wing Surface Mount Option 300 Package	Extra-Insulation Wide-Body Package	Hermetic MIL-H-38534 Package	Description/Application
	17 MHz	0.25%	122 dB	HCPL-4562	HCNW-4562		Ideally suited for coupling Video Signals
	13 MHz	0.15%	119 dB				
	9 MHz	Not Specified		6N135/6 HCPL-2530/1		4N55 HCPL-55XX HCPL-65XX	Dual-channel devices can be used to build servo-type and differential dc isolation amplifiers
	85 KHz	0.1%	140 dB	HCPL-7800/A/B			Ideally suited for motor-current and voltage sensing applications
	200 KHz	0.05%	140 dB	HCPL-7820			
				HCPL-7840			
	1 MHz	0.01%	95 dB		HCNR200 HCNR201		A simple device that can be used to build a variety of isolation amplifiers. The input LED illuminates two closely matched photo-diodes. One photo-diode is at the output, and another is used for feedback.

Notes:

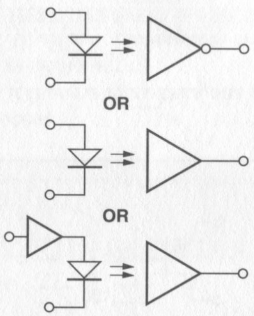
1. All above optocouplers are UL1577 (V_{ISO} = 2500 V rms/1 min) and CSA approved.
2. HCPL-7800/A/B and HCPL-7820/40 are VDE 0884 approved (V_{IORM} = 600 V rms).
3. HCNR200/1 with Option 50 is VDE 0884 approved (V_{IORM} = 1000 V rms).
4. Contact your HP representative for availability of Option 060 (VDE 0884, V_{IORM} = 300 V rms), and Option 020 (UL1577, V_{ISO} = 5000 V rms/1 min).

Table 4. Digital Interface Optocouplers

Device	Typical Signalling Data Rate (KBd)	Max. t_{PROP} (μs)	Input On-Current (mA)	Minimum CMTR dV/dt (V/μs)	Minimum CMTR V_{CM} (V)	V_{CC} Range	6 or 8-pin DIP and Gull-Wing Surface Mount Option 300 Single Channel Package	6 or 8-pin DIP and Gull-Wing Surface Mount Option 300 Dual Channel Package	Small-Outline SO-8 Single Channel Package	Small-Outline SO-8 Dual Channel Package	Extra Insulation Wide-Body Package	Hermetic MIL-H-38534 Package
	3	500	0.5	500 (Typ.)	0	1.5-18	4N45 4N46					
	100	10	0.5	1,000	10	1.6-18	6N138 6N139	HCPL-2730 HCPL-2731	HCPL-0700 HCPL-0701	HCPL-0730 HCPL-0731	HCNW138 HCNW139	
	100	100	0.5	500	50	2.0-18						6N140A HCPL-57XX HCPL-67XX
	3	500	0.040	1,000	1.0	1.6-18	HCPL-4701	HCPL-4731	HCPL-070A	HCPL-073A		
	1,000	1	16	1,000 (typ)	10 (typ)	1.5-30	6N135 6N136 HCPL-4502	HCPL-2530 HCPL-2531	HCPL-0500 HCPL-0501 HCPL-0452	HCPL-0530 HCPL-0531 HCPL-0534	HCNW135 HCNW136 HCNW4502	
				15,000	1,000	1.5-30	HCPL-4503	HCPL-4534	HCPL-0453		HCNW4503	
	700	6	16	1000	10	2-18						4N55 HCPL-55XX HCPL-65XX

Notes:
1. If there is more than one part number in a line item, the specification shown is for the highest grade part number. Refer to individual data sheets for exact specifications and test conditions.
2. All above optocouplers are UL1577 (V_{IORM} = 2500 V rm/1 min) and CSA approved.
3. HCNW135/6/8/9 and HCNW4502/3 optocouplers are VDE 0884 approved (V_{IORM} = 1,000 V rms).
4. Contact your HP representative for availability of Option 060 (VDE 884, V_{IORM} = 300 V rms), and Option 020 (UL1577, V_{IORM} = 5000 V rms/1 min).

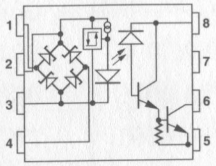
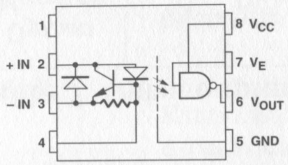
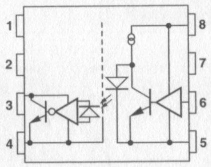
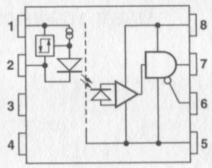
Table 4. Digital Interface Optocouplers (cont'd.)

Device	Typical Signalling Data Rate (KBd)	Max. t_{PROP} (µs)	Input On-Current (mA)	Minimum CMTR dV/dt (V/µs)	Minimum CMTR V_{CM} (V)	V_{CC} Range	6 or 8-pin DIP and Gull-Wing Surface Mount Option 300 Single Channel Package	6 or 8-pin DIP and Gull-Wing Surface Mount Option 300 Dual Channel Package	Small-Outline SO-8 Single Channel Package	Small-Outline SO-8 Dual Channel Package	Extra Insulation Wide-Body Package	Hermetic MIL-H-38534 Package
	5	0.3	1.6			4.5-20	HCPL-2200 HCPL-2201 HCPL-2202	HCPL-2231	HCPL-0201		HCNW2201	
				10,000	1,000		HCPL-2211 HCPL-2212	HCPL-2232	HCPL-0211		HCNW2211	
			2	1000	50							HCPL-52XX HCPL-62XX
	8	0.2	0.5	400 (Typ.)	50	4.75 5.25	HCPL-2300					
	10	0.06	6	500	50	4.75-5.25						6N134 HCPL-56XX HCPL-66XX
	10	0.1	5			4.5-5.5	6N137 HCPL-2601		HCPL-0601	HCPL-0631	HCNW2601 HCNW137	
				10,000	1000		HCPL-2611	HCPL-4661	HCPL-0611	HCPL-0661	HCNW2611	
			2				HCPL-261A	HCPL-263A	HCPL-061A	HCPL-063A		
				10,000	1000		HCPL-261N	HCPL-263N	HCPL-061N	HCPL-063N		
	20	0.06	4			4.75-5.25	HCPL-2400	HCPL-2430				
				10,000	300		HCPL-2411					
				500	50							HCPL-54XX HCPL-64XX
	50	0.07	0.001	2000	200	4.5-5.5	HCPL-7100 HCPL-7101					

Notes:

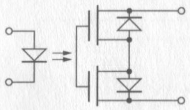
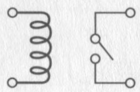
1. If there is more than one part number in a line item, the specification shown is for the highest grade part number. Refer to individual data sheets for exact specifications and test conditions.
2. All above optocouplers are UL1577 (V_{ISO} = 2500 V rms/1 min) and CSA approved.
3. HCPL-7100/1 optocouplers are VDE0884 approved (V_{IORM} = 600 V rms/1 min).
4. HCNW2201/2211/2601/2611 and HCNW137 optocouplers are VDE0884 approved (V_{IORM} = 1000 V rms/1 min).
5. Contact your HP representative for availability of Option 060 (VDE0884, V_{IORM} = 300 V rms/1 min), and Option 020 (UL1577, V_{ISO} = 5000 V rms/1 min).

Table 5. Application Specific Optocouplers

Device	Description	8-pin DIP and Gull-Wing Surface Mount Option 300 Package	Hermetic MIL-H-38534 Package	Key Characteristics
	AC/DC Voltage Threshold Sensing Optocoupler with a TTL compatible output.	HCPL-3700	HCPL-5700/1	2.5 mA Threshold Current
		HCPL-3760	HCPL-5760/1	1.2 mA Threshold Current
	Optically Coupled Line Receiver with built-in line termination.	HCPL-2602/12	HCPL-1930/1	Typical signalling rate: 10 MBd; Typical common-mode transient rejection: 10,000 V/µs
	Optically Coupled 20 mA Current Loop Transmitter with TTL/CMOS Interface.	HCPL-4100		Up to 400 m distance at 20 KBd. Higher signalling rates can be obtained at shorter distances.
	Optically Coupled 20 mA Current Loop Receiver with TTL/CMOS Interface	HCPL-4200		

Notes:
1. All above optocouplers are UL1577 (V_{ISO} = 2500 V rms/1 min) and CSA approved.
2. Contact your HP representative for availability of Option 060 (VDE0884, V_{ISO} = 300 V rms/1 min).

Table 6. Solid State Relays

Device	Output Withstand Voltage @ 25°C	Maximum Load Current @ 25°C	Typical Output On-Resistance @ 25°C	Typical Output Off-Leakage @ 25°C	Typical Output Off-Capacitance V_O = 25 V	6- or 8-pin DIP or Gull-Wing Surface Mount Option 300 Package	Hermetic MIL-H-38534 Package
Actual circuit 	90 Volt	0.8/1.6 A	0.4 Ω	0.1 nA (V_O = 90 V)	145 pF		HSSR-7110/1
	60 Volt	0.75/1.5 A	0.4 Ω	0.1 nA (V_O = 60 V)	135 pF	HSSR-8060	
Equivalent Relay Circuit 	400 Volt	150/300 mA	6 Ω	0.6 nA (V_O = 400 V	60 pF	HSSR-8400	

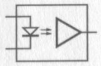
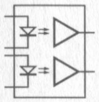
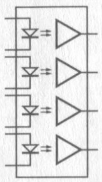
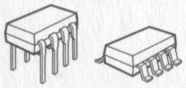
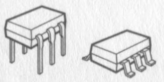
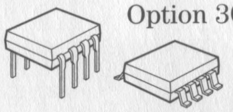
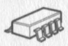
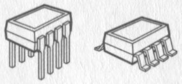
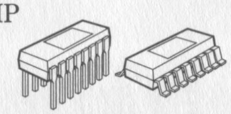
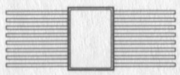
Note:
1. HSSR-8060/8400 solid state relays are UL508 and CSA approved.

Table 7. Optocoupler Options

Option Number	Description	Available Package Type			
		Plastic DIP	Plastic Widebody	Plastic SO	Hermetic
001	Commercial Burn-in	●	●	●	
002	100% Screening Program	●	●	●	‡
020	5000 Vac/1 min. UL Rating*	●	‡		
100	Butt Joint Surface Mount				●
200	Solder Dip Leads				●
300	Gull-Wing Surface Mount	●	●	‡	●
500	Tape and Reel Packaging	●	●	●	

Note: Contact factory for restrictions on these options.
*Limited product types.
‡Standard feature; you need not order this option.

Table 8. Optocoupler Package Selection

		Body Dimensions (mm) L x W x H	Single Channel 	Dual Channel 	Quad Channel 	Withstand Voltage Rating
Plastic Package	8-Pin DIP  Option 300	9.6 x 6.3 x 4.2	●	●		2,500 Vac/1 min; 3,750 Vac/1 min* ; 5,000 Vac/1 min., Option 020*
	6-Pin DIP  Option 300	9.6 x 6.3 x 4.2	●			2,500 Vac/1 min
	Extra Insulation 8-Pin Wide-Body  Option 300	11.1 x 9.0 x 4.0	●			5,000 Vac/1 min
	Small Outline SO-8 	5.1 x 3.9 x 3.2	●	●		2,500 Vac/1 min
Hermetic Package with MIL-H-38534	8-pin DIP  Option 300	9.6 x 7.8 x 3.0	●	●		1,500 Vdc/5s
	16-pin DIP  Option 300	20.4 x 7.8 x 3.0		●	●	1,500 Vdc/5s
	LCC 	8.9 x 8.9 x 2.0		●		1,500 Vdc/5s
	Flat-Pack 	11.0 x 7.1 x 2.8			●	1,500 Vdc/5s

*Some 8-pin DIP optocouplers have 3750 Vac/1 min rating, and some have 5000 Vac/1 min rating with Option 020.

Note: Refer to individual data sheets for exact specifications.

Design Considerations

Insulation and Regulation of Optically Coupled Isolation Devices

The primary purpose of optocoupler devices is to provide both electrical insulation and signal isolation. The popularity of Hewlett-Packard's product offering can be accredited to cost-effective innovations in these areas. Yet there exists a surprising level of misunderstanding regarding these two terms from both vendor and user alike. The discrepancies that exist within the worldwide regulatory community add to the frustration level for many designers. This discussion attempts to help the designer capitalize on HP's knowledge.

Insulation Defined

The electrical insulating capability of an optocoupler, sometimes referred to as withstand voltage, is determined by its ability to protect surrounding circuitry, as well as itself, against physical damage resulting from different voltage potentials. This potentially damaging phenomena can be system induced (e.g., motor rail voltage) or externally coupled (e.g., lightning pulse). The insulating material between input and output as well as the packaging technology are the primary determinants of withstand voltage capability. In contrast, signal isolation, although sharing some common causes, defines the ability of the optocoupler to prevent the distortion of data through the suppression and filtration of common-mode transients. A further discussion of signal isolation can be found in the section entitled "Common-Mode Transient Rejection."

The effects of repeated long-term high-voltage stress between input and output of an optocoupler has continued to be an area of uncertainty. Much of the technical emphasis has been on the ability of optocouplers to withstand one-time short-term high-voltage transients (e.g., U.L. 1 minute dielectric voltage withstand rating). Hewlett-Packard has conducted extensive operating life tests to determine the effects of continuous high-voltage stress, both transient as well as steady-state, on the degradation of insulating performance. On completion, the test data was analyzed to determine safe operating areas for steady-state input-output high-voltage stress. The boundary conditions, as shown in Figures 1, 2, 3, have been defined by Hewlett-Packard as Endurance Voltage. The lower region refers to the safe operating area for the application of continuous steady-state ac and dc input-output voltage stress, or working voltage, and the middle region to transient voltage stress. Operation above these regions has shown to cause wear-out either in functionality or insulating capability and is not recommended. Endurance Voltage is based on the inherent properties of Hewlett-Packard optocouplers that utilize unique packaging technologies and does not apply to products manufactured by other vendors. In addition, as these tests do not take into consideration particular equipment use conditions, Hewlett-Packard recommends the designer consult the appropriate regulatory agency guidelines to determine applicable working voltage. For an in-depth discussion on Endurance Voltage, consult Hewlett-Packard Application Note AN1074.

Regulatory Environment

Because electrical insulation is a function of safety, optocoupler performance, both at component and system levels, is often subject to regulatory requirements and approvals that vary according to country as well as industry. Most agencies are a mixture of governmental and private organizations with industry representation. Some common regulatory agencies are listed in Table 9.

Category 1 Optocouplers

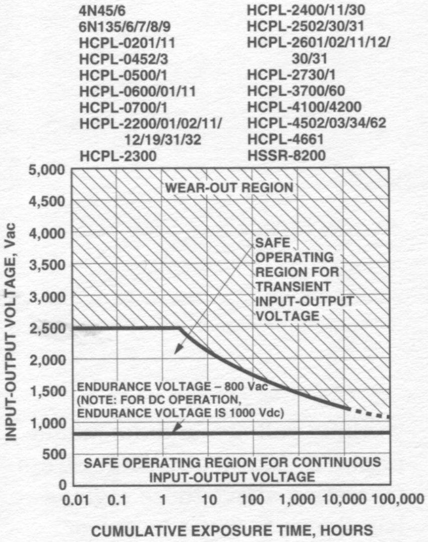


Figure 1. Recommended Safe Operating Area for Input-Output Voltage-Endurance Voltage for Category 1 Optocouplers.

Category 2 Optocouplers:

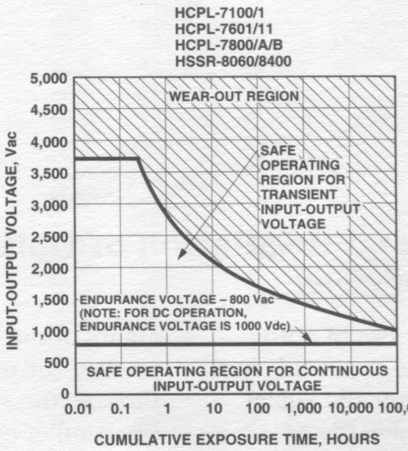


Figure 2. Recommended Safe Operating Area for Input-Output Voltage-Endurance Voltage for Category 2 Optocouplers.

Category 3 Optocouplers:

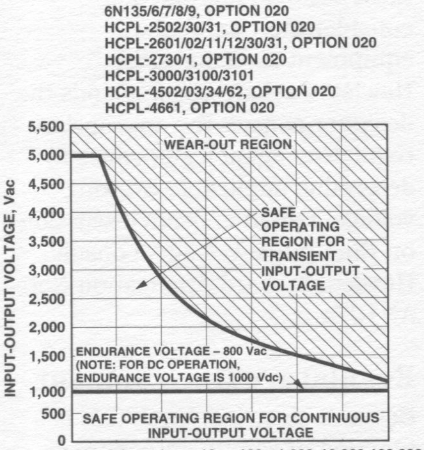


Figure 3. Recommended Safe Operating Area for Input-Output Voltage-Endurance Voltage for Category 3 Optocouplers.

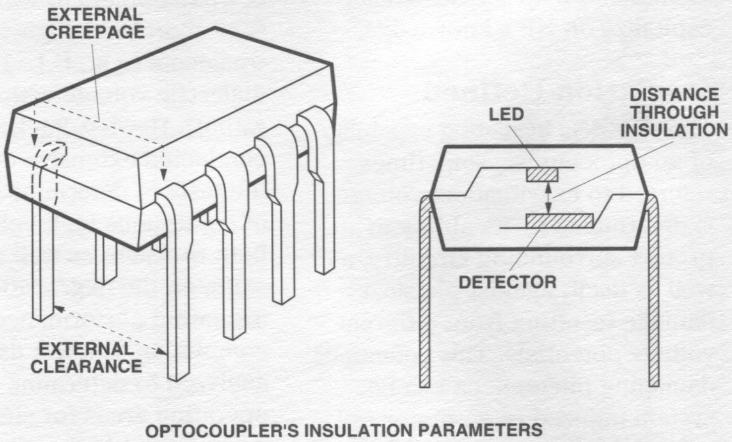


Figure 4. Optocoupler's Insulation Parameters.

WARNING: In all cases where regulatory compliance is required, working voltage as defined by the regulatory agency cannot be exceeded.

Table 9

COMMON REGULATORY AGENCIES		
Name	**Country**	**Abbreviation**
Verband Deutscher Electrotechniker	Germany	VDE
Underwriters Laboratories	United States	UL
Canadian Standards Association	Canada	CSA
British Standards Institute	United Kingdom	BSI
Norge Elektriske Materielkontrol	Norway	NEMKO
Danmarks Elektriske Materielkontrol	Denmark	DEMKO
Svenska Elektriske Materielkontrollanstalten AB	Sweden	SEMKO
Sahkotarkastuskeskus Elinspektionscentralen	Finland	SETI

Currently, little conformity exists between the various agencies regarding mechanical configurations and electrical test requirements. Within the European Union, however, standardization of equipment as well as component level specifications is in progress. In the interim, testing and approval according to equipment type and environmental factors must be obtained according to the control documents of each country. The International Electrotechnical Commission (IEC), with worldwide representation, provides a forum for generating technical standards. The European Committee for Electrotechnical Standardization (CENELEC), has European Commission authority to adopt IEC standards as European Norms (EN), with the force of law.

Common Terms

External Clearance
The shortest distance through air, between conductive input and output leads, measured in mm. Refer to Figure 4.

Comparative Tracking Index (CTI)
Outer molding material characterization in the presence of aqueous contaminants. The higher the CTI value, the more resistant the material is to electrical arc tracking. CTI is often used with creepage by safety agencies to determine working voltage.

External Creepage
The shortest distance along the outside surface, between input and output leads, measured in mm. Refer to Figure 4.

Dielectric Insulation Voltage Withstand Rating
The ability to withstand without breakdown a 60 second application of a defined dielectric insulation voltage between input and output leads.

Distance Through Insulation
Distance between the photoemitter and photodetector inside optocoupler cavity (also called internal clearance). Refer to Figure 4.

Installation Class

- I Equipment in closed systems (e.g., telecom) protected against overvoltage with devices such as diverters, filters, capacitors, etc.
- II Energy consuming equipment (e.g., appliances) supplied through a fixed installation.
- III Primarily equipment in fixed installations (e.g., fixed industrial equipment).
- IV Primary supply level for industrial factories.

Insulation
Operational - required for correct equipment operation but not as a protection against electric shock.
Basic - protects against electric shock.
Supplementary - independently applied to basic insulation to protect against shock in the event of its failure.
Double - composed of both basic and supplementary.
Reinforced - A single insulation system composed of several layers (e.g., single and supplementary).

Internal Clearance
See Distance Through Insulation.

Internal Creepage
The shortest border distance between two separate insulating materials measured between emitter and detector.

Material Group (see Comparative Tracking Index)

I 600 < CTI
II 400 < CTI < 600
IIIa 175 < CTI < 400
IIIb 100 < CTI < 175

Partial Discharge
Electric discharge that partially bridges the insulation between two electrodes. Hewlett-Packard supports partial discharge measurements per VDE0884, a technique developed to evaluate the integrity of insulating materials. VDE's philosophy is that partial discharge testing offers advantages over Dielectric Withstand Voltage testing, which might adversely affect the insulating material, and over through insulation distance requirements which not only increase manufacturing costs but also do not necessarily result in acceptable insulating capability.

Pollution Degree

1 - Nonconductive pollution only.
2 - Only occasional, temporary conductivity due to condensation.
3 - Frequent conductive pollution due to condensation.
4 - Persistent conductive pollution due to dust, rain or snow.

Rated Mains Voltage
Primary power voltage declared by manufacturer. Used to categorize optocoupler maximum allowable working voltage.

For an in depth discussion on regulatory design requirements and device specifications, please refer to Hewlett-Packard's Optoelectronics Designer's Catalog. Hewlett-Packard also plans to publish a comprehensive Regulatory Application Note by December, 1995. Contact your authorized HP sales representative for more information.

Common-Mode Transient Rejection

Circuit designers often encounter the adverse effects of common-mode noise in a design. Once a common-mode problem is identified, there are several ways that it can be resolved. However, common-mode interference manifests itself in many ways; therefore, it may be hard to determine whether it is the cause of a circuit's misbehavior. If a system is connected and running but only produces erroneous data, common-mode noise may be the reason. This section describes sources of common-mode problems, presents possible solutions, and highlights the technology that Hewlett-Packard Components Group uses to produce opto-isolators with superior Common-Mode Performance.

Common-mode rejection (**CMR**) is a measure of the ability of a device to tolerate common-mode noise. Hewlett-Packard specifies common-mode rejection as **common-mode transient rejection** (**CMTR**). CMTR describes the maximum tolerable rate-of-rise (or fall) of a common-mode voltage (given in volts per microsecond). The specification for CMTR also includes the amplitude of the common-mode voltage (V_{CM}) that can be tolerated. Common-mode interference that exceeds the maximum specification might result in abnormal voltage transitions or excessive noise on the output signal. (CMTR is slightly different than common-mode rejection ratio **CMRR**, often used for analog devices and commonly specified in dB as the ratio of the differential-mode gain to the common-mode gain.)

HP optocouplers rely on two key technical strengths to achieve high CMTR. The first is use of a proprietary, low-cost Faraday shield which decouples the optocoupler input side from the output side. The second method is by unique package design which minimizes input-to-output capacitance. The importance of these two strengths is explained as follows.

Figure 5 illustrates a Common-mode transient pulse (V_{CM}).

Figure 6a and 6b show interference circuit models for two types of possible common-mode failure mechanisms for a single-transistor optocoupler. The dashed lines are shown to indicate external components added to the optocoupler. V_{CM} represents a voltage spike across the optocoupler isolation path between the output-side ground (V_{G2}) and input-side ground (V_{G1}). V_{DM} represents a signal voltage applied across the input side.

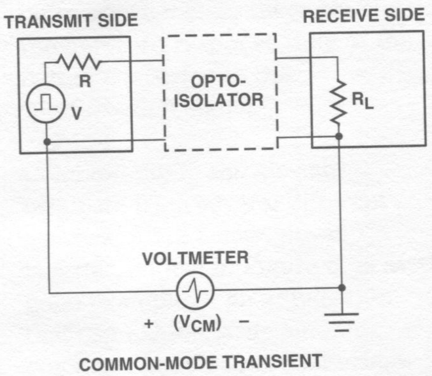


Figure 5. Illustration of V_{CM} Common-Mode Pulse.

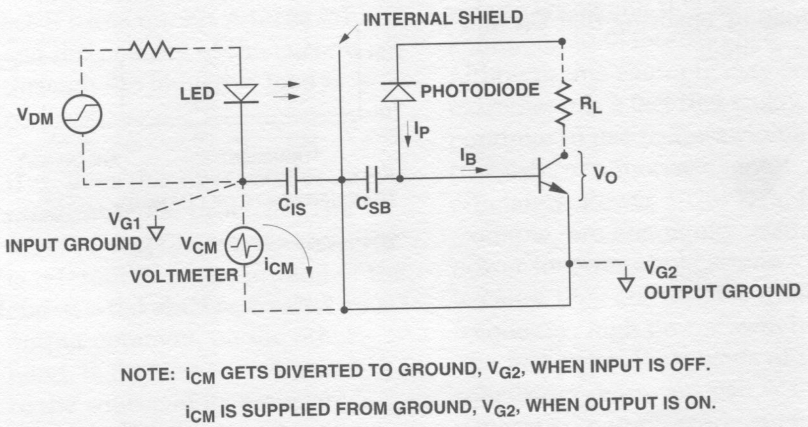


Figure 6a. Interference Circuit Model.

Referring to Figure 6a the parasitic distributed capacitance C_{IS}, which might tend to couple transient current into the transistor base node (for example when the transistor is in the "off" state) terminates on an internal Faraday shield. Therefore the transient current, I_{CM}, gets diverted to output ground (V_{G2}). Referring to Figure 6b, the parasitic distributed capacitances, C_{IA} and C_{IC} are shown across the LED anode-to-ground (V_{G2}) and LED cathode-to-ground (V_{G2}) respectively. Because the LED anode is at a relatively higher impedance than the cathode (i.e., R_{LED} to ground) current at this point will tend to be modulated slightly during CM transients. For instance, if the LED is on, then during a positive transient (i.e., $dV_{CM}/dt > 0$) current will be diverted away from the LED. For fast enough transients, this may turn the LED off. (If R_{LED} is connected to the LED cathode side then C_{IC} provides a parasitic path to divert current towards or away from the LED.) This type of failure is avoided by ensuring that C_{IA} and C_{IC} are small.

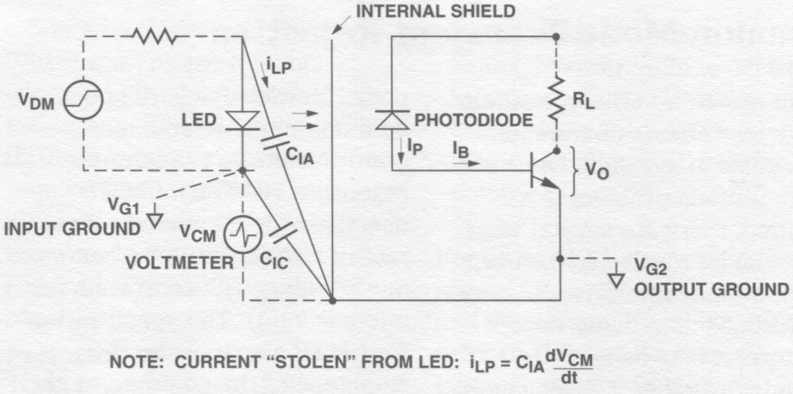


Figure 6b. Interference Circuit Model.

Figure 7 shows the possible effect on the output voltage level of an optocoupler due to a common-mode pulse. The output is shown (successively) in the high and low states. (This might be observed if R_{led} were connected as in Figures 6a, 6b.)

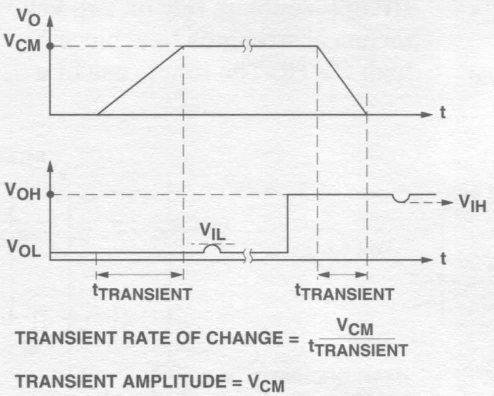


Figure 7. Common Mode Interference Effect.

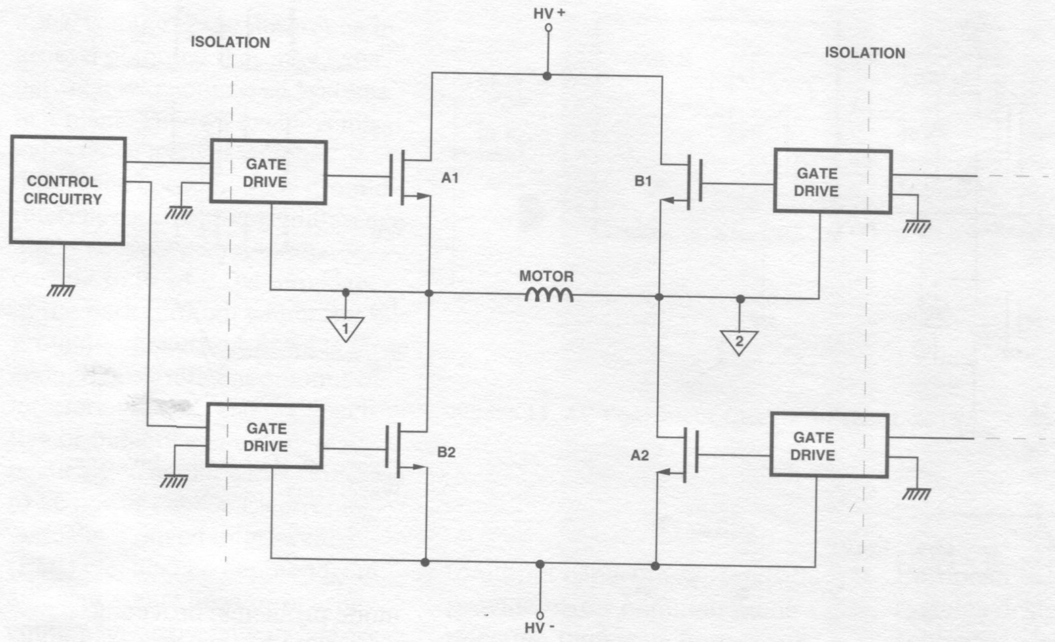


Figure 8. Full-Bridge Power Switch Configuration.

As long as the amplitude V_{CM} and value of dV_{CM}/dt are less than the ratings for the optocoupler being used, V_{OH} will remain above 2 V (maximum TTL V_{IH}) and V_{OL} will remain below 0.8 V (minimum TTL V_{IL}). Note that the slight perturbations in output voltage occur sometime after the input pulse which causes them, due to the non-zero response time of the output transistor to the "perturbation signal."

Common-mode signals can originate from several different sources. A full bridge power inverter, shown in Figure 8, is a good example of an application that can exhibit large amounts of common-mode noise. Full-bridge inverters are commonly found in motor-speed control and switching power supply applications. The power inverter is generally used to produce an ac output from a dc input. In a full-bridge inverter application like that shown in Figure 8, the source of one set of transistors (A1, B1) is attached to the drain of a second set of transistors (A2, B2). When transistor set A turns on, set B turns off. Current flows from the positive supply, through transistor A1, through the load, and through transistor A2. When set B turns on, set A turns off, and the polarity of the current through the inductive load is reversed.

How does this operation create a common-mode problem? The input of each gate drive circuitry is referenced to the ground of the digital control circuitry; the output common, on the other hand, is floating and referenced to the source of its associated power transistor. The floating commons of the upper gate drive circuits rapidly switch between the positive and negative power supplies. This rapid switching creates a large voltage swing across the input to output of the gate drive circuitry. As an example, a half bridge circuit that switches between +250 V and -250 V in 100 ns creates a common-mode transient signal of 5000 V/µs with an amplitude of 500 V (see Figure 9). The device that carries the control information to each MOSFET must be able to withstand this level of common-mode interference. Although this example may seem extreme, it is a fact that engineers continue to use faster-switching transistors to increase motor efficiency. Power MOSFETs, for example, are commonly used in power inverter applications because they are capable of high frequency, high power switching. The fast switching speeds of the transistors, however, can generate common-mode signals with very high rates of change (dV_{CM}/dt).

The common-mode signal rate of rise can also be affected by the reverse recovery characteristics of diodes D1 and D2 in the power

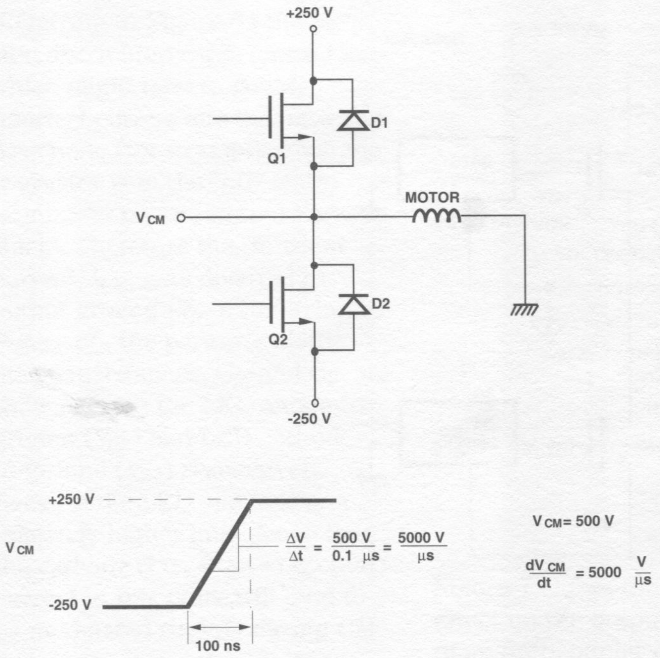


Figure 9. Half-Bridge Example.

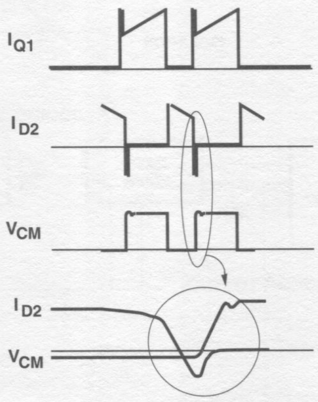


Figure 10. Half-Bridge Inverter Waveforms.

inverter shown in Figure 9; these diodes are often referred to as "freewheeling" diodes. If the inverter is driving an inductive load, such as a motor winding, these diodes may become forward biased during the normal operation of the inverter. For example, assume that Q1 of Figure 9 is turned on, Q2 is off, and current is flowing through Q1 and into the inductive load. When Q1 turns off, voltage V_{CM} swings in the negative direction until diode D2 becomes forward biased and conducts the load current.

It is when Q1 turns back on that very high rates of rise can be generated. In extreme cases, when Q1 turns on again, the rate of rise of voltage V_{CM} is determined by how quickly diode D2 recovers from forward conduction. The voltage and current waveforms shown in Figure 10 illustrate what happens when Q1 turns back on. As Q1 starts to turn on, the current through D2 begins to decrease. The current through D2 continues to decrease and actually goes negative for a short time due to the storage of minority carrier charge in its junction. It is when this charge has been depleted that D2 begins to turn off and V_{CM} begins to increase. If D2 turns off very quickly, V_{CM} can also rise very quickly, generating a large common-mode transient signal.

For the particular case of driving the gate of an IGBT or power MOSFET in a power inverter, the HCPL-3120 IGBT/MOSFET gate drive optical isolator is an effective solution for common-mode problems, providing protection against common-mode transients with slew rates as fast as 15 kV/μs at V_{CM} as high as 1500 V.

High electrical noise levels can also contribute to common-mode problems. A significant amount of electrical noise is found in industrial environments as a result of the starting and operating of electric motors. When a large motor first turns on, it normally requires a large in-rush current to reach operating speed. This large current spike can generate a significant amount of electrical noise in its own and nearby systems. Even the electric motors in a typical household environment vary in size from fractional to low integral horsepower units and are often noisy ac-operated or brushed dc-motors. Other sources of electrical noise include microwave ovens, welding equipment, and automobile ignitions.

Common-mode noise can enter a system through conductive, inductive, or capacitive coupling. An example of a "conducted" noise voltage is the difference in ground potential that may exist between two connected systems in a plant. The two systems may experience a small voltage difference between their ground references. This voltage difference might cause a ground-loop current to flow. If the impedance of the path through which the ground-loop current flows is large enough, a significant amount of interference will result. Capacitive or inductive coupling may occur when signal wires run close to ac power cables. Electromagnetically induced interference (EMI) can also be coupled from adjacent signal lines or nearby equipment, especially in factory environments. Other sources of common-mode noise that can be coupled into a system include lightning strikes and electrostatic discharge (ESD).

Optical isolation is a useful technique for reducing common-mode interference. Optocouplers, like transformers and capacitively-coupled devices, provide isolation between the input and output of a system. Transformers, by virtue of their high primary-to-secondary capacitance, tend to have lower CMTR capability. Capacitively-coupled devices tend to have poor CMTR capability (since in these devices fast, transient common-mode pulses pass across the coupling capacitor and are not filtered out.) Optocouplers, having low input-to-output capacitance, typically provide better common-mode rejection than transformers or capacitively-coupled devices. The CMR specification of an optocoupler ranges up to V_{CM} = 1500 V amplitude and up to 15,000 V/µs rate of change of V_{CM}, for high-CMR products.

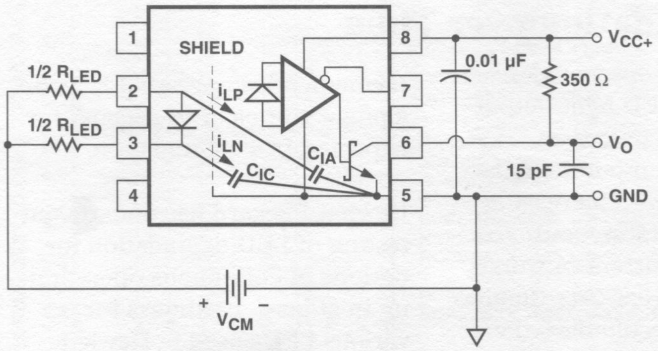


Figure 11. AC Equivalent Circuit for HCPL-261X.

Another advantage of optocouplers lies in the area of EMI generation and susceptibility. Transformers typically radiate electromagnetic interference (EMI) and are susceptible to magnetic fields. Capacitively-coupled devices generate ground-loop current, thus generating EMI. Optocouplers use light for data transmission; additionally, they effectively eliminate ground-loop current. Therefore, they do not radiate nor are they affected by stray magnetic fields. This ability is well-recognized in the European Community where systems designers need to achieve system-level standards (now adopted as EN50081/EN50082 which set limits on the amount of acceptable EMI a system radiates or to which it is immune.)

A technique which may be used to further enhance CMTR is an "LED split-resistor" technique as shown in Figure 11; (note that the V_{DM} which would appear between the top and bottom R_{LED}s has not been shown in this "ac equivalent circuit"). By using two LED-resistors (instead of one) the current change at the anode of the LED is nearly canceled by the current change at the cathode, thus tending to keep the LED current constant. This makes the optical isolator more immune to CM transients where C_{LA} and C_{LC} limit CMTR.

LED Degradation over Time

One concern for optocoupler lifetime is that LED light-output (LOP) decreases over time. Generally, light-output degradation gets worse with increasing operating temperature and operating LED current. A worst-case scenario is that over time, as the LED becomes dimmer, the LOP will fall below the minimum value needed for a part to switch properly. Hewlett-Packard, an industry leader in LED technology, tests LOP degradation under accelerated conditions in order to provide designers with information on the expected operating lifetime of optocouplers. Optocouplers which have an input driver IC are designed such that the driver IC sets the proper input I_F, guardbanding for expected LED LOP degradation over the life of the optocoupler. (Examples are the HCPL-3700, HCPL-7101, and HCPL-7820.) On the other hand, optocouplers requiring an input current-setting resistor (i.e., without an input driver IC) require that the circuit designer guardband the minimum recommended operating I_F by an amount sufficient to account for expected LOP degradation.

Hewlett-Packard has undertaken testing of LED degradation for periods of continuous operation up to at least 10 khours for various LEDs used in Hewlett-Packard optocouplers. Figures 12a and 12b show the normalized light output over a 10,000 hour period for Gallium Arsenide Phosphide (GaAsP) and Aluminum Gallium Arsenide (AlGaAs) LEDs respectively.

Figure 13 shows LOP as a function of I_F for a GaAsP LED under operating conditions of I_F = 20 mA at an ambient temperature of T_A = 125°C. Curves are shown for t = 0 hours and t = 10 khours of continuous operation.

Optocouplers which use the GaAsP and AlGaAs LEDs are listed in Figures 12a and 12b.

Figure 14 illustrates how, based on knowledge of initial and post-stress LOP vs. I_F, (for a GaAsP LED) a minimum guardbanded I_F can be determined to provide for LOP degradation over the life of the LED. For this case, the minimum recommended I_F at t = 0 hours ($I_{F(min)}$) of 5 mA is guardbanded for 10 khours of operation to a value of 6.1 mA.

Note that in Figure 14 if the LOP vs. I_F curves were linear over the range between $I_{F(min)}$ and $I_{GB(min)}$ (minimum I_F guardbanded for t = 10 khours) then the amount of guardbanding (percent change) would be equal to the amount of LOP degradation (percent change). Since in our case the curve is "concave up" the amount of guardbanding is slightly less than the percent change in LOP between t = 0 and t = 10 khours. Figure 15 (which is a plot of the slope of the (t = 0) curve in Figure 14), shows that the slope is increasing up to about I_F = 20 mA, at which point it flattens out and begins decreasing.

By empirically modeling the typical GaAsP LOP vs. I_F curve and applying knowledge of worst-case (-3 σ) degradation over time, guardbanded $I_{GB(min)}$ for a typical LED can be reduced to the following equation:

$$I_{GB(min)} = \frac{I_{F(min)}}{\delta^{\frac{1}{a}}}$$

$$\approx I_{F(min)} \times 1.214$$

where,

$I_{F(min)}$ = minimum recommended I_F at t = 0 hours.

$I_{GB(min)}$ = minmum guardbanded I_F after t = 10 khours.

a = 1.3 (empirical curve - fit)

δ = Post-stress LOP Factor ($\approx$ 0.784 for 10 khours, T_A = 125°C, I_F = 20 mA)

This equation applies well when I_F is approximately constant.

Example: To calculate the appropriate $I_{GB(min)}$ for an HCPL-3120 note that $I_{F(min)}$ = 7 mA. Applying the above relationship for 10 khour guardbanding, $I_{GB(min)}$ = 8.50 mA.

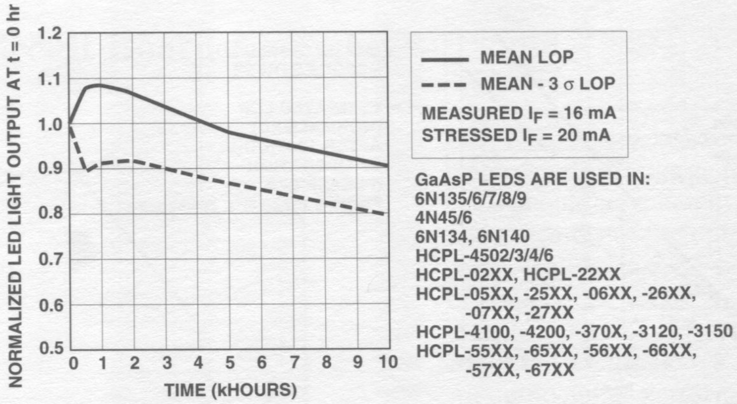


Figure 12a. Normalized LED Light Output (LOP) vs. Time for GaAsP LED (Stress I_F = 20 mA, T_A = 125°C).

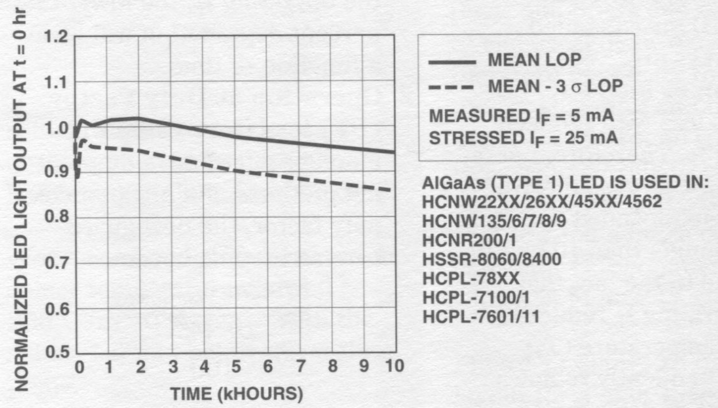


Figure 12b. Normalized LED Light Output (LOP) vs. Time for AlGaAs LED (Stress I_F = 25 mA, T_A = 125°C).

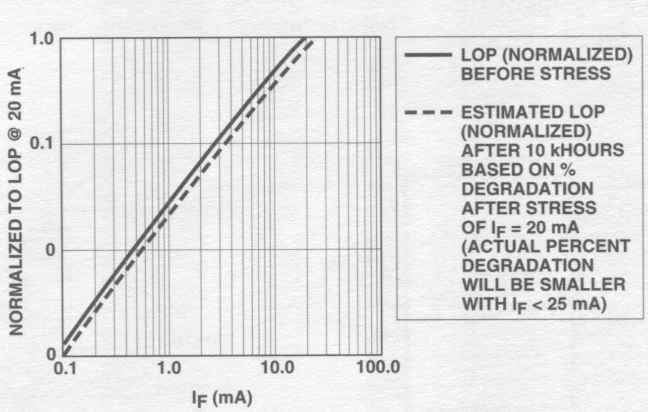


Figure 13. Typical GaAsP LED Light-Output (LOP) vs. I_F After 0 khours and 10 khours of Continuous Operation at 125°C, I_F = 20 mA.

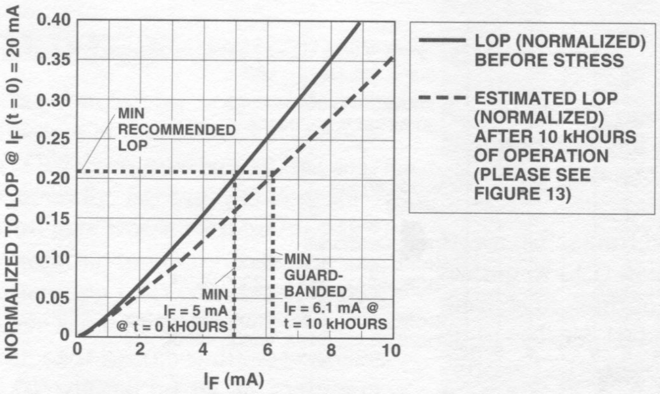


Figure 14. GaAsP LED Light Output (LOP) vs. I_F on a Linear Scale (Stressed at T_A = 125°C, T_F = 20 mA).

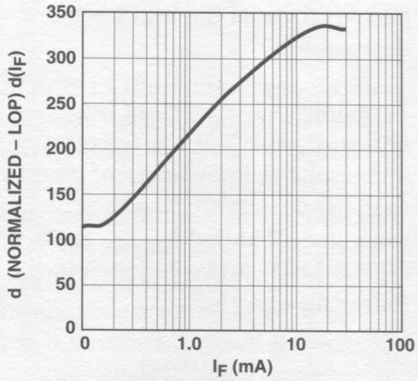


Figure 15. Slope of Typical GaAsP LOP vs. I_F.

Factors which will increase expected LED guardbanded-operation times are:

1. **Operation at lower I_F**: LOP decreases less with reduced operating I_F. Therefore, operation at $I_{GB} < I_F <$ 20 mA will result in guardbanded operating lifetimes longer than 10 khours. This is due to the fact that lower operating I_F reduces junction temperature (T_J) which subsequently reduces the amount of degradation over time. Generally, the lower the operating I_F, the lower the percent degradation will be as a function of time.
2. **Operation at Duty Factor (DF) less than 100%** will increase guardbanded operating lifetimes. For any particular duty factor, the new guardbanded lifetime becomes:

$$\frac{lifetime_{continuous}}{\frac{DF\,(\%)}{100}}$$

3. **Operation at ambient temperature T_A < 125°C** will also decrease the amount of LOP degradation (again, due to decreased T_J) increasing operation lifetime.

Hewlett-Packard also has LED degradation data available for other LED types. AlGaAs LEDs tend to be more linear than GaAsP LEDs and display less degradation over time than GaAsP. Therefore the calculations used here can be applied with confidence to optocouplers using AlGaAs LEDs. For further specific questions, please contact your local HP sales representative.

Guidelines for Printed Circuit Board Assembly and Layout

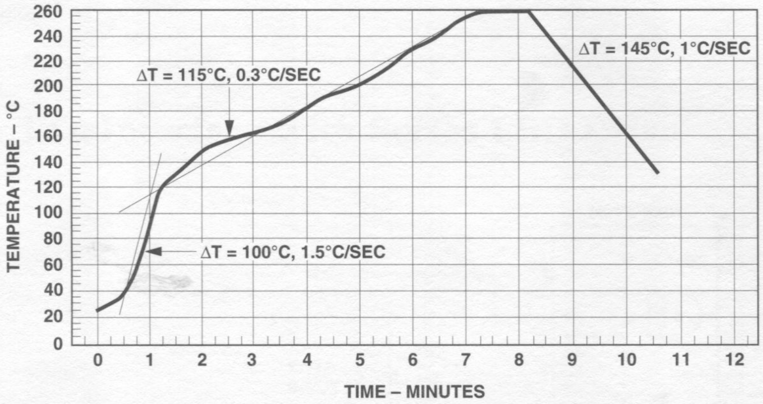


Figure 16. Maximum Solder Reflow Thermal Profile.

HP optocouplers are suitable for automatic printed circuit board (PCB) assembly operations including surface mount assembly. The following guidelines are recommended for proper operation and long term reliability of HP optocouplers.

Solder Reflow Process: Only one soldering operation is recommended within the thermal profile shown in Figure 16. With infrared lamp heating, use precautions to avoid localized temperature rise in the resin. Also, the resin should not be immersed in the solder. To prevent chloride corrosion of the lead frame, halide fluxes should not be used.

Wave Soldering: The maximum solder temperature allowed is 260°C for 10 seconds, with the solder 1.6 mm below the seating plane.

Solvent Cleaning: The solvent temperature and immersion time should not exceed 45°C and three minutes respectively. For ultrasonic cleaning, environmentally safe solvents such as ethyl and methyl alcohol are recommended.

ESD Precautions: Standard electrostatic discharge precautions should be taken in handling and assembly of the optocouplers to prevent damage or degradation of the device.

Printed Circuit Board Layout: An optocoupler performs reliably only in a correctly designed circuit. In most digital optocouplers the amplifier at the output is required to operate with the very low photocurrent from the photodetector. Consequently these amplifiers can be sensitive to electrical disturbances. It is therefore necessary to have proper shielding and bypassing of the V_{CC} and Ground traces. Bypassing closely to each of the optocouplers V_{CC}-to-Ground pins with low-inductance ceramic capacitor is recommended as shown in Figure 17.

Figure 17 shows an optional PCB layout for a high speed digital optocoupler for improving electrical noise immunity. The optional V_{CC} and Ground traces between the pin rows of the optocoupler help shield the output circuitry from electrical disturbances on the input pins, thus improving common-mode rejection.

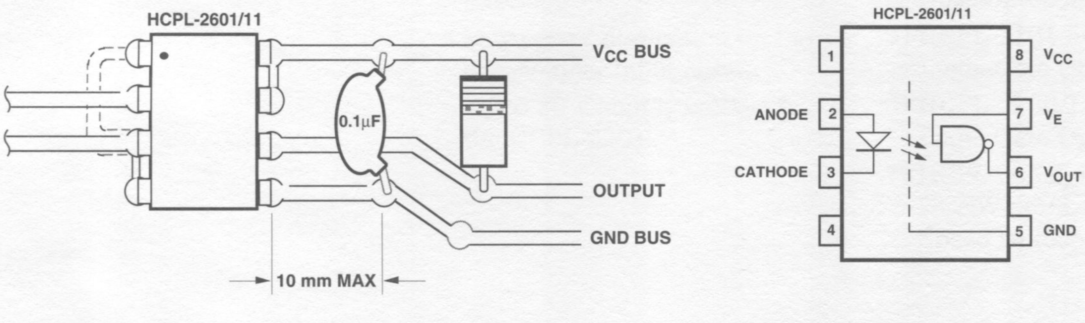
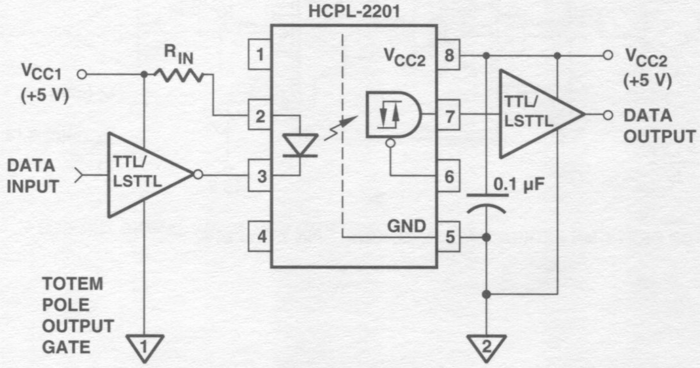


Figure 17. Optional Printed Circuit Board Layout for Improved Electrical Noise Immunity.

Digital Logic Interface/Level Shifting Applications

TTL Interface with Series LED Drive



$$R_{IN} = \frac{V_{CC1} - V_F - V_{OL}}{I_F}$$

RECOMMENDED $R_{IN} = 1.1\ k\Omega$

Description

The circuit shown is an interface between two TTL gates using an active output (totem pole) optocoupler, the HCPL-2201. A series switching circuit drives the optocoupler LED. The designer chooses R_{IN} to agree with the equation shown in the schematic. The active output of the HCPL-2201 can be directly connected to a TTL gate, and no pull-up resistor is required. The HCPL-2201 can sink enough current to handle up to 16 LSTTL or 4 TTL loads.

Performance of Circuit

- Maximum optocoupler propagation delay: 300 ns (refer to alternative HP parts for lower propagation delay times)
- Typical signaling rate: dc to 5 MBd (refer to alternative HP parts for higher speeds)
- Typical optocoupler LED drive current: 2 mA

Benefits

- No pull-up resistor required on the optocoupler output interface
- Low power dissipation on the optocoupler input circuit
- Up to 20 V supply voltage for the HCPL-2201

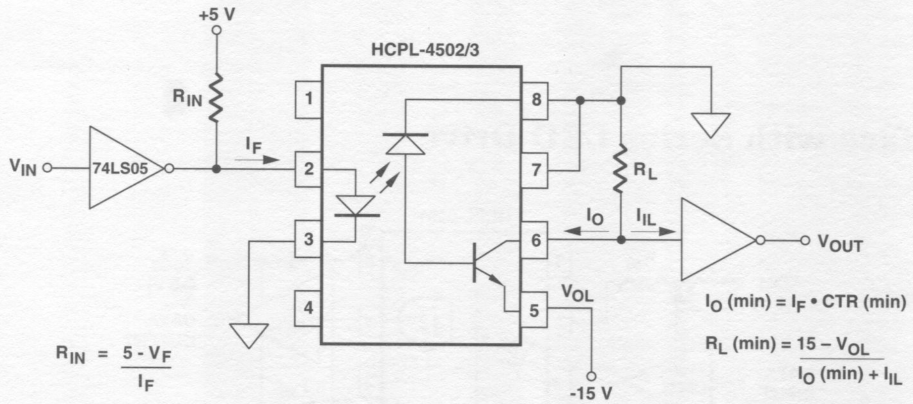
References

HCPL-2201 Logic Gate Optocoupler Technical Data

Alternative HP Parts

1) HCPL-07XX, HCPL-2730/1, HCPL-4701, 6N138/9, CNW138/9 Low Input Current Optocouplers
2) HCPL-0201/11 Small-Outline Logic-Gate Optocoupler
3) HCPL-52XX Hermetic Logic-Gate Optocoupler
4) CNW2201/11 Widebody Logic-Gate Optocoupler
5) HCPL-7101 50 MBd CMOS Logic-Gate Optocoupler
6) HCPL-2230/1 Dual-Channel Logic-Gate Optocoupler
7) HCPL-05XX, HCPL-2530/1, HCNW135/6, 6N135/6 High Speed Optocoupler

Level Shifting/TTL Interface with Shunt LED Drive



NOTE: FOR BEST CMR PERFORMANCE, CONNECT PIN 7 TO PIN 8.

Description

The above circuit shows how a 0 to 5 V logic signal can be level shifted to a -15 to 0 V signal. The circuit can safely be used for level shifting up to ± 800 V. The circuit uses an open collector output logic gate, the 74LS405, to drive the LED of the HCPL-4502/3 optocoupler. The HCPL-4502/3 also has an open-collector output. The designer chooses R_{IN} to agree with the equation shown in the schematic. This equation sets the value of the optocoupler LED forward current. The output of the HCPL-4502/3 requires a pull-up resistor, R_L. The current-transfer ratio (CTR) of the opto-coupler determines the maximum amount of current the optocoupler output can sink while maintaining the output voltage (between pins 5 and 6) of 0.5 V or less.

Performance of Circuit

- Maximum optocoupler propagation delay: 2 µs (refer to alternative HP parts for lower propagation delays)
- Typical signaling rate: dc to 1 MBd (refer to alternative HP parts for higher speeds)
- Typical optocoupler LED drive current: 10 to 16 mA
- Maximum output supply voltage (pins 8-5): 30 V
- Minimum CMR: 15 kV/µs slew rate, 1500 V peak

Benefits

- Reduces transient immunity problems
- Convenient way of replacing pulse transformer for high-voltage level shifting

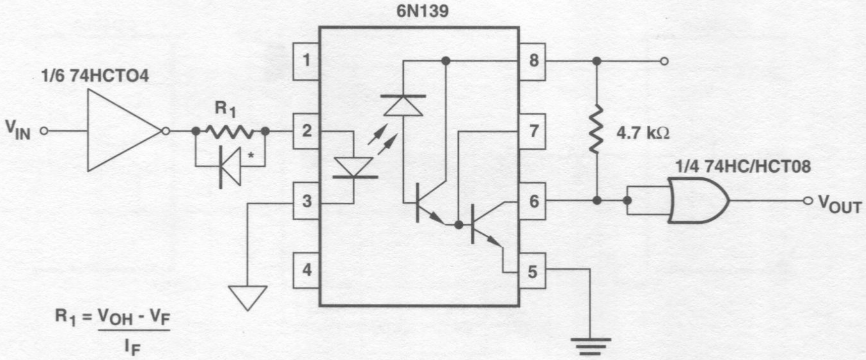
References

HCPL-4502/3 High Speed Optocoupler Technical Data

Alternative HP Parts

1) HCPL-07XX, HCPL-2730/1, HCPL-4701, 6N138/9, HCNW138/9 Low Input Current Optocouplers
2) HCPL-55XX Hermetic High Speed Optocoupler
3) HCPL-7101 50 MBd CMOS Logic Gate Optocoupler

Low Power 100 kBd CMOS Interface



* USE ANY SIGNAL DIODE FOR CMR PROTECTION

Description

A CMOS-to-CMOS interface is possible with HP optocouplers. The above circuit shows a cost-effective interface for 100 kBd applications. The 74HCT04 CMOS Hex Inverter that drives the optocoupler LED can source and sink up to 4 mA current. The 6N139 optocoupler requires only 0.5 mA LED current for operation. The signal diode across resistor R_1 protects against common-mode transient voltages and is optional. The output circuit uses a 74HCT08 so that the signal from V_{IN} to V_{OUT} is not inverted.

Performance of Circuit

- Minimum optocoupler LED turn-on current: 0.5 mA (The HCPL-4701 optocoupler requires only 40 µA)
- Typical signaling rate: dc to 100 kBd
- Minimum optocoupler current transfer ratio: 400%

Benefits

- Low power consumption
- Simple interface

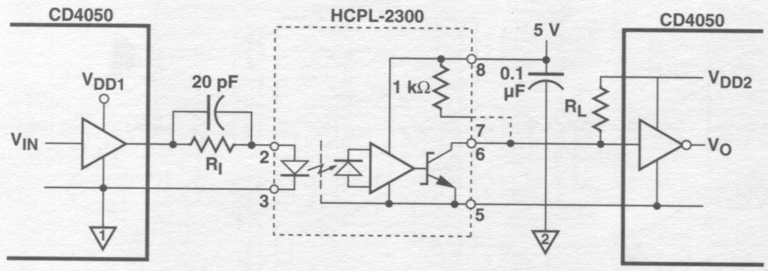
References

HCPL-0700/11 High Gain Optocoupler Technical Data

Alternative HP Parts

1) HCPL-4701 Very Low Power High Gain Optocoupler
2) HCPL-2730/1 Dual Channel High Gain Optocoupler
3) HCPL-M700/1, HCPL-0731 Small Outline High Gain Optocoupler
4) HCPL-57XX, HCPL-67XX, 6N140 Hermetic High Gain Optocoupler

Low Power 8 MBd CMOS Interface



V_{DD1} (V)	R_I (kΩ)	R_L (kΩ)	V_{DD1} (V)
5	5.11	1	5
10	13.3	2.37	10
15	19.6	3.16	15

Description

A CMOS-to-CMOS interface is possible with HP optocouplers. The above circuit shows an interface circuit for 8 MBd applications. Over the temperature range a CMOS CD4050 Hex Buffer can source about 0.7 mA (minimum), which is sufficient to drive the HCPL-2300 optocoupler. The 20 pF capacitor allows peaking currents to assist the LED turn on and off quickly.

Performance of Circuit

- Optocoupler LED current: 0.5 mA minimum
- Typical signaling rate: dc to 8 MBd

Benefits

- Low power consumption
- Simple interface

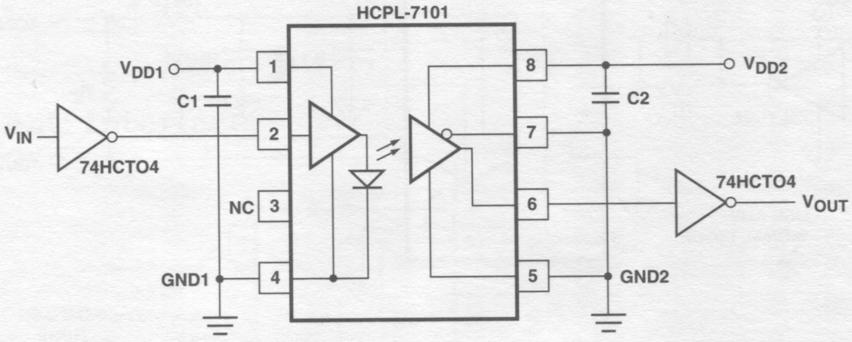
References

HCPL-2300 Low Input Current High Speed Optocoupler Technical Data

Alternative HP Parts

HCPL-7100/1 High Speed CMOS Optocoupler

50 MBd CMOS Interface



C1, C2 = 0.01 μF TO 0.1 μF

Description

Up to 50 MBd CMOS-to-CMOS interface is possible with the HCPL-7100 optocouplers. The above circuit requires only a bypass capacitor on each of the HCPL-7101 input-side and output-side power supply pins.

Performance of Circuit

- Typical logic high input power supply current for HCPL-7101: 10 mA
- Typical logic high output power supply current for HCPL-7101: 9 mA
- Typical HCPL-7101 signaling rate: dc to 50 MBd
- Typical HCPL-7101 pulse-width distortion: 2 ns
- Typical HCPL-7101 propagation delay: 28 ns

Benefits

- Low power consumption
- Very simple interface

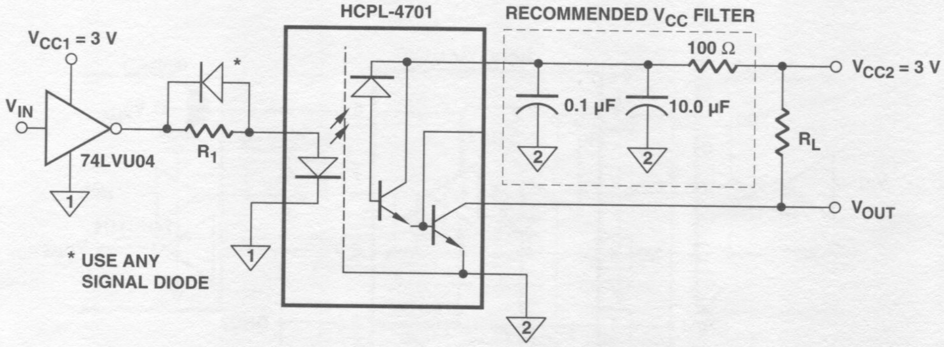
References

HCPL-7100/1 High Speed CMOS Optocoupler Technical Data

Alternative HP Parts

HCPL-2300: 8 MBd Low Input Current Optocoupler

Isolated 3 V Logic Interface/Battery Operated Applications



TYPICAL POWER DISSIPATION FOR 3 V APPLICATION
(V_{CC1}, V_{CC2} = 3.0 V, R_L = 11 kΩ, R_1 = 43.8 kΩ)

V_{CC1} SIDE:

OPTOCOUPLER LED	50 µW
INPUT RESISTOR R_1	70 µW
TOTAL V_{CC1} SIDE	120 µW

V_{CC2} SIDE:

OPTOCOUPLER (V_O, V_{CC2})	85 µW
PULL-UP RESISTOR R_L	790 µW
TOTAL V_{CC2} SIDE	875 µW

Description

The HCPL-4701 low-power optocoupler is used for 3 V-to-3 V Logic interface across an isolation barrier. Only 40 µA of LED current (I_F) is required to turn-on the optocoupler. Typical power for dissipation for just the optocoupler is 135 µW at I_F = 40 µA, and 965 µA at I_F = 500 µA.

Performance of Optocoupler

- Typical optocoupler current transfer ratio: 3500% at I_F = 40 µA
- Input current for optocoupler turn-on: 40 µA

Benefits

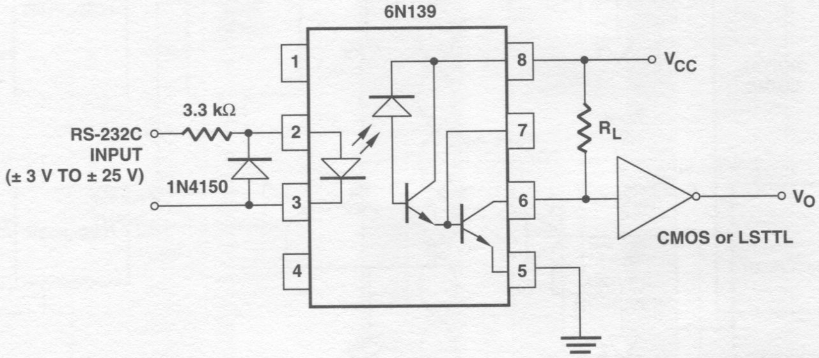
- Low power dissipation

References

HCPL-4701 Low Power Optocoupler Technical Data

Data Communications Applications

Isolated RS-232C Interface



Description

The above schematic shows a very simple RS-232C data communication isolation interface using a 6N139 optocoupler. This circuit operates with an LED forward current of 0.5 mA when the input is at 3 V. The 1N4150 diode protects the LED during negative signal voltages. Since a low diode current is used to operate the 6N139, the twisted pair line can be up to 120 m. However, the data rate may have to be lowered to account for slower charging and discharging of the total line capacitance.

Performance of Circuit

- RS-232C link twisted pair cable length: up to 120 m for low data rates
- Typical optocoupler propagation delay: 20 µs

Benefits

- Simple, low cost isolated interface
- Meets worldwide regulatory standards for isolation

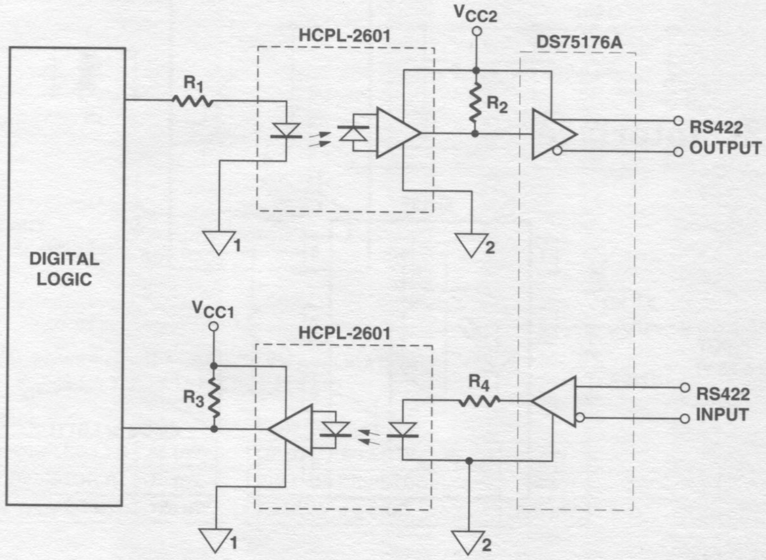
References

6N139: High-Gain, Low Input Current Optocoupler

Alternative HP Parts

1) HCPL4701, 6N138/9, 4N45/6, HCPL-2730/1 High-Gain, Low Input Current Optocoupler
2) HCPL-0700/1, HCPL-0730/1, HCPL-M700/1 Small Outline High-Gain, Low Input Current Optocoupler

Isolated RS-422 Interface



Description

The above isolated RS-422 circuit uses two high-speed optocouplers that can switch up to 10 MBd signals. An isolated power supply (V_{CC2}) is required to power the DS75176A driver/receiver integrated circuit.

Performance of Circuit

- Typical signaling rate: up to 10 MBd
- Optocoupler LED drive current: 5 mA
- Typical Optocoupler Transient Rejection: 10,000 V/µs slew rate, 50 V peak (higher transient rejection with HCPL-2611)

Benefits

- Compact design with small outline optocouplers
- Prevents common-mode transients from interfering with the signal

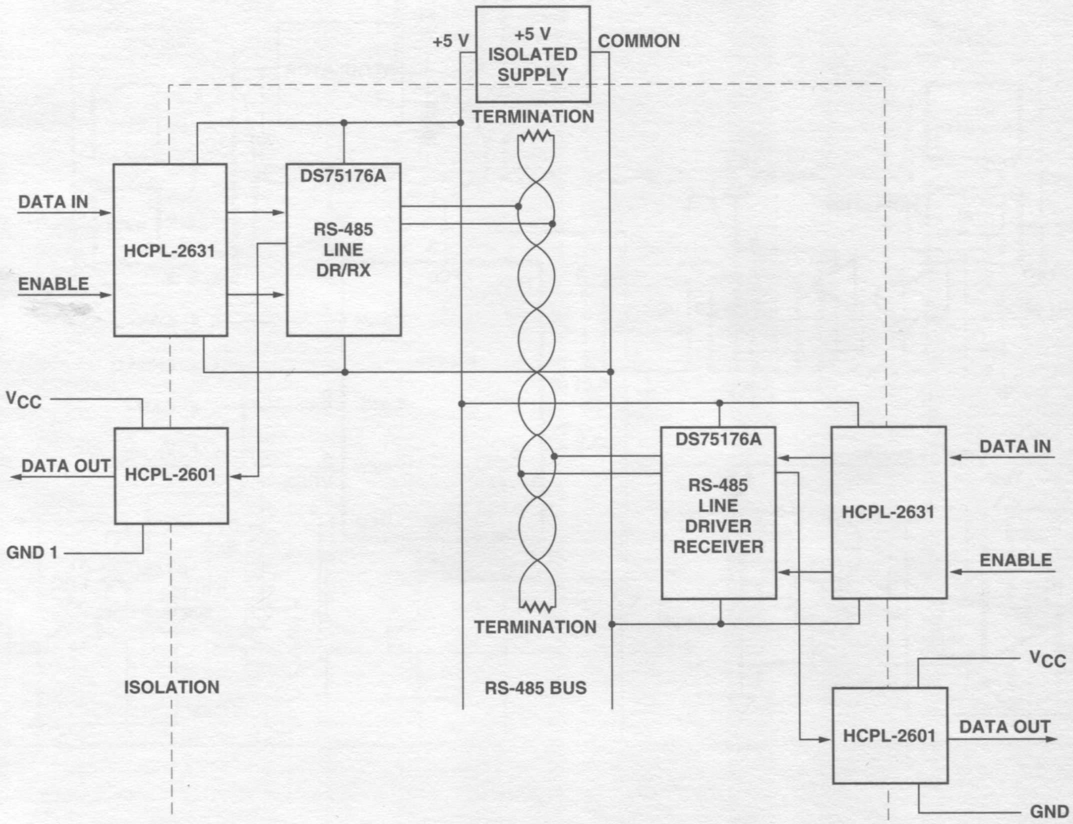
References

HCPL-0601 Small Outline High Speed Optocoupler Technical Data

Alternative HP Parts

1) HCPL-0611 High-CMR, Small Outline High Speed Optocoupler
2) HCPL-2611 High Speed, High CMR Optocoupler
3) HCNW2601/11 Widebody High Speed Optocoupler
4) HCPL-5601 Hermetic High Speed Optocoupler

Isolated RS-485 Bus Interface



Description

The above isolated RS-485 interface circuit uses the HCPL-26XX High Speed CMOS optocoupler, which can transmit digital signals faster than 10 MBd. An isolated 5 V power supply is required to power the RS-485 bus side of the circuit.

Performance of Circuit

- Typical optocoupler signaling rate: greater than 10 MBd
- Typical optocoupler propagation delay: 28 ns
- Typical optocoupler pulse-width distortion: 2 ns

Benefits

- Low signal distortion
- Good transient immunity

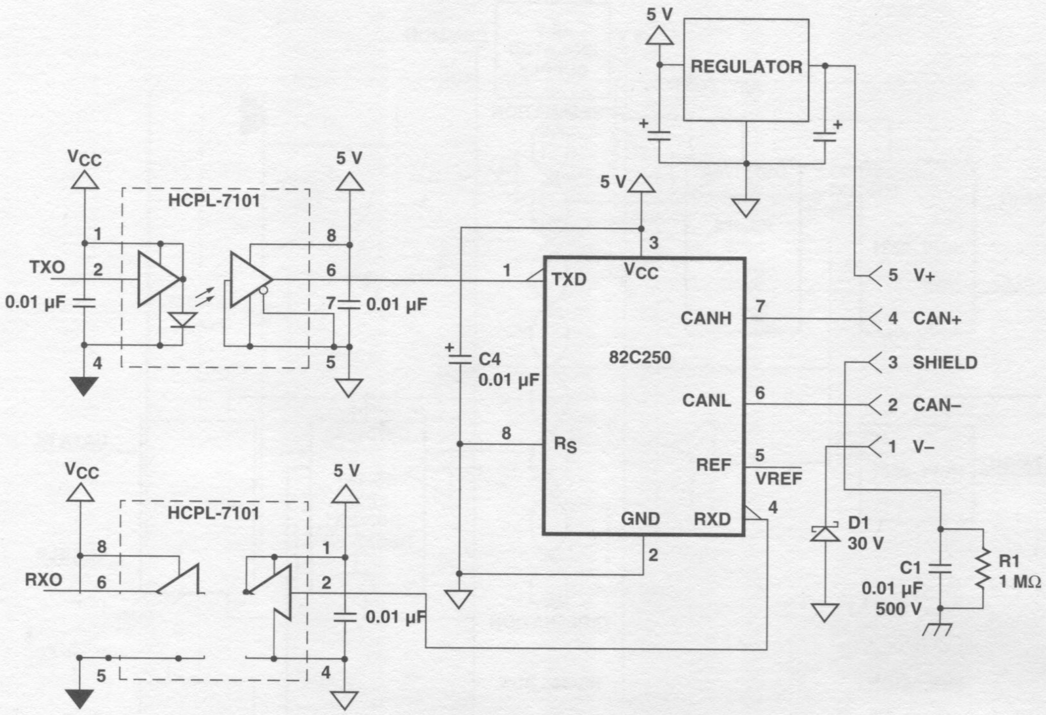
References

HCPL-26XX High Speed Optocoupler Technical Data

Alternative HP Parts

1) HCPL-2400/30 High Speed Optocoupler
2) HCPL-7101 High Speed CMOS Optocoupler
3) HCPL-5430 Hermetic High Speed Optocoupler

Isolated DeviceNet/CAN Interface



Description

DeviceNet, a factory floor communication network standard, sometimes may require connecting devices to be electrically isolated. The HCPL-7101, high speed CMOS optocoupler with a 40 ns maximum propagation delay time meets the DeviceNet Physical layer specification.

Performance of Optocoupler

- Signaling rate: up to 50 MBd
- Typical propagation delay: 28 ns
- Typical pulse-width distortion: 2 ns

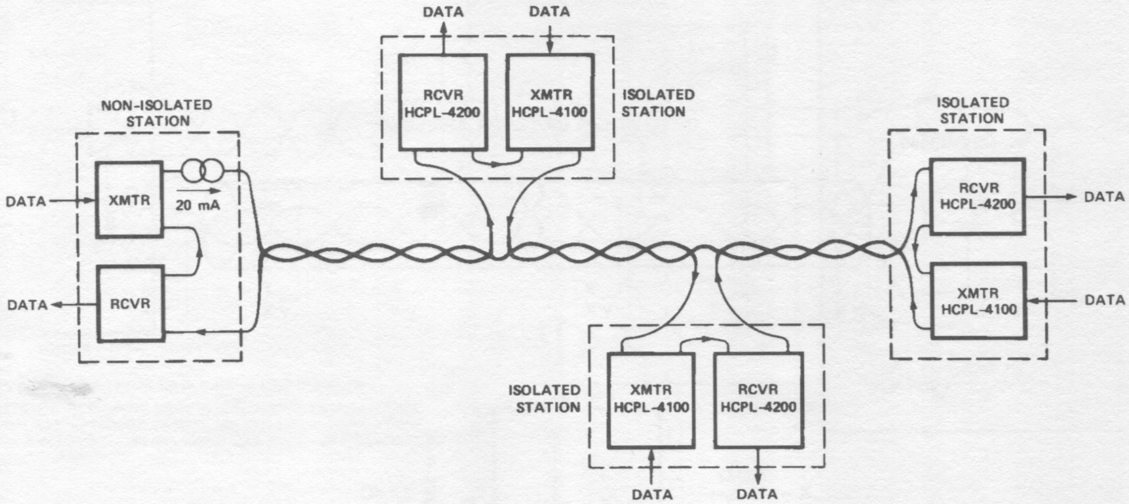
Benefits

- Fast data access time or latency
- Elimination of transients results in high data integrity
- Meets worldwide isolation safety standards: UL, CSA, VDE

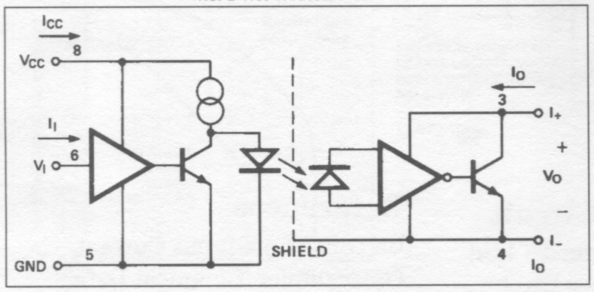
References

1) HCPL-7101 High Speed optocoupler Technical Data
2) DeviceNet Specification, Allen Bradley Company

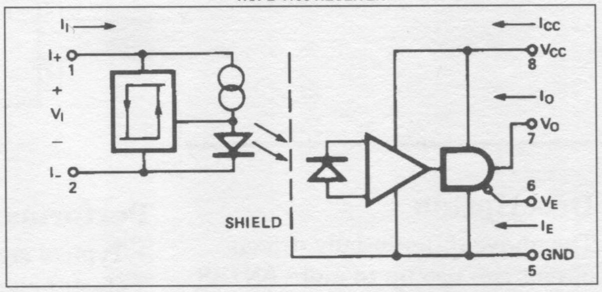
Isolated 20 mA Current Loop Interface



HCPL-4100 TRANSMITTER



HCPL-4100 RECEIVER



Description

The above half-duplex, point-to-point, multi-drop, 20 mA current loop configuration can alternatingly transmit bi-directional data over two wires. Only one current source is required. Each isolated station with an HCPL-4100 transmitter and HCPL-4200 receiver optocouplers provides excellent common-mode rejection.

Performance of Circuit

- 1 mA noise margin in the "space" state
- 8 mA noise margin in the "mark" state
- Typical signal rate and distance: 40 m at 100 kBd; over 200 m at 10 kBd

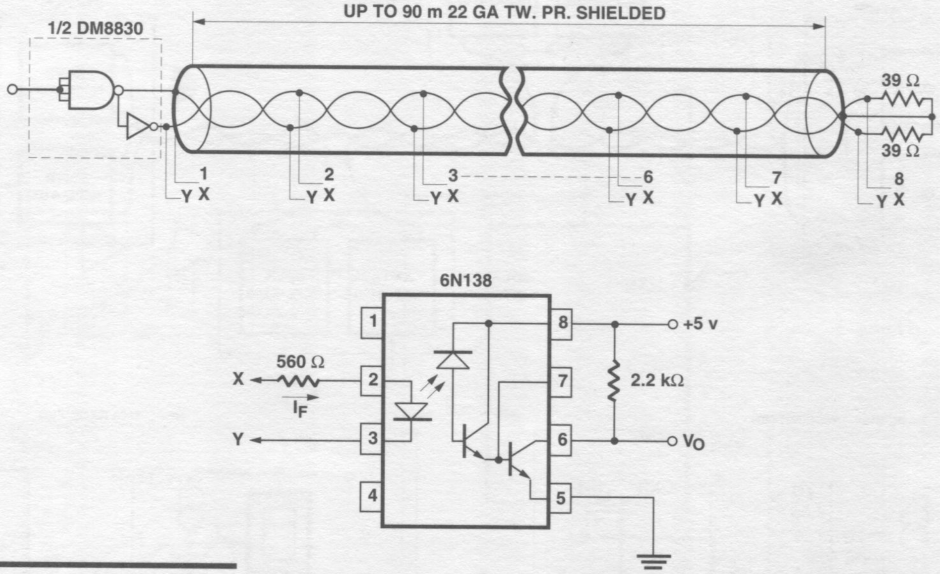
Benefits

- Maintains data integrity
- Simple data transmission system for industrial applications

References

1) HCPL-4100/4200 20 mA Current Loop Optocoupler Technical Data
2) Application Note AN1018, "Designing with the HCPL-4100 and 4200 Current Loop Optocoupler"

Multidrop Line Receiver



Description

The above differentially driven circuit can use up to eight 6N138 optocouplers at various receivers along the 90 m line. All stations are isolated. The first station would draw approximately 2.7 mA current, and the last station 1.8 mA of LED drive current. The output grounds of the optocoupler may be electrically separate.

Performance of Circuit

- Typical signaling rate: 18 kBd (faster signaling rates can be obtained with HCNW139 and 6N139)
- Typical optocoupler propagation delay time: t_{PHL} = 2 µs; t_{PLH} = 20 µs
- Up to 90 m distance

Benefits

- Simple, low-cost, multidrop circuit for low signaling rates

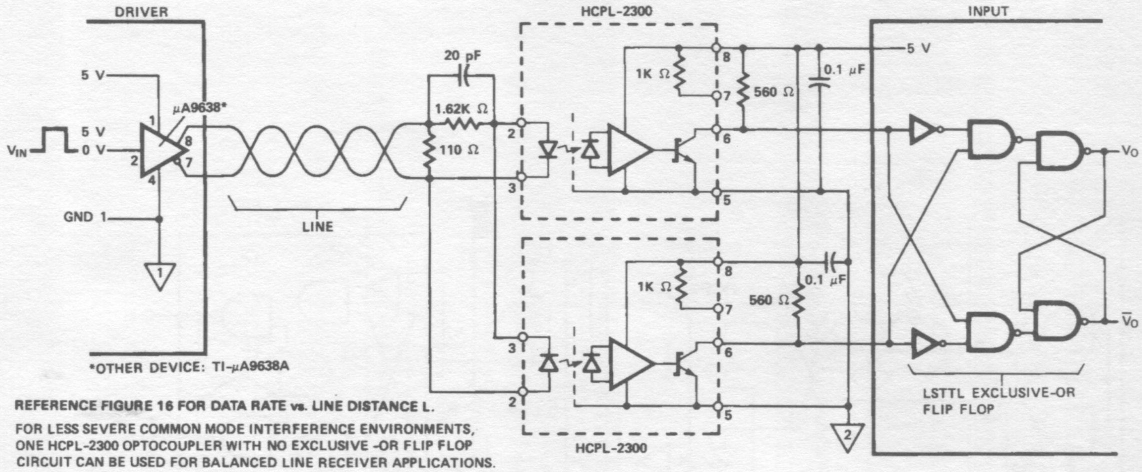
References

6N138/9 Low-Input Current Optocoupler Technical Data

Alternative HP Parts

1) HCPL-0700/01/30/31, HCPL-M700/1, HCNW138/9, and HCPL-2730/31 Low-Input Current Optocouplers
2) HCPL-57XX, HCPL-67XX, and 6N140 Hermetic Low-Input Current Optocouplers
3) HCPL-2300 High Speed, Low Input Current Optocoupler

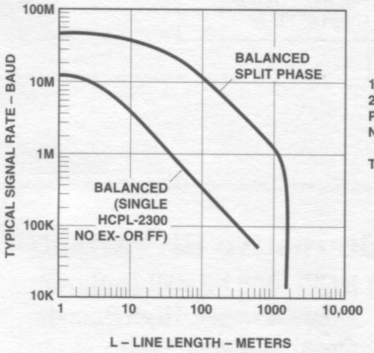
Isolated Balanced Line Receiver - Circuit No. 1



*OTHER DEVICE: TI-µA9638A

REFERENCE FIGURE 16 FOR DATA RATE vs. LINE DISTANCE L.

FOR LESS SEVERE COMMON MODE INTERFERENCE ENVIRONMENTS, ONE HCPL-2300 OPTOCOUPLER WITH NO EXCLUSIVE -OR FLIP FLOP CIRCUIT CAN BE USED FOR BALANCED LINE RECEIVER APPLICATIONS. $V_O = V_{IN}$.



10% PULSE WIDTH DISTORTION
22 AWG UNSHIELDED TWISTED PAIR WIRE CABLE (DEARBORN NO. 862205)

$T_A = 25\ °C$

Description

A balanced RS-422 line driver differentially drives a twisted pair line. Two HCPL-2300s provide balanced signal direction for this line. The thresholds of the HCPL-2300 will be nearly equal, providing symmetrical signal detection level. Since the propagation delays of the two optocouplers are similar, the pulse-width distortion for this scheme will be quite low for considerable line lengths. The Exclusive-Or flip-flop circuit at the optocoupler output increases CMR protection to an extremely high level and balances the propagation delays. For less demanding noise environments, only one HCPL-2300 with no EX-OR flip-flop may be used. The maximum data rate, however, will be somewhat lower.

Performance of Circuit

- Signaling rate: > 10 MBd at 100 m line length
- Common mode rejection: > 15,000 V/µs

Benefits

- Very high common-mode transient rejection
- Data transmission for up to 1 km distance

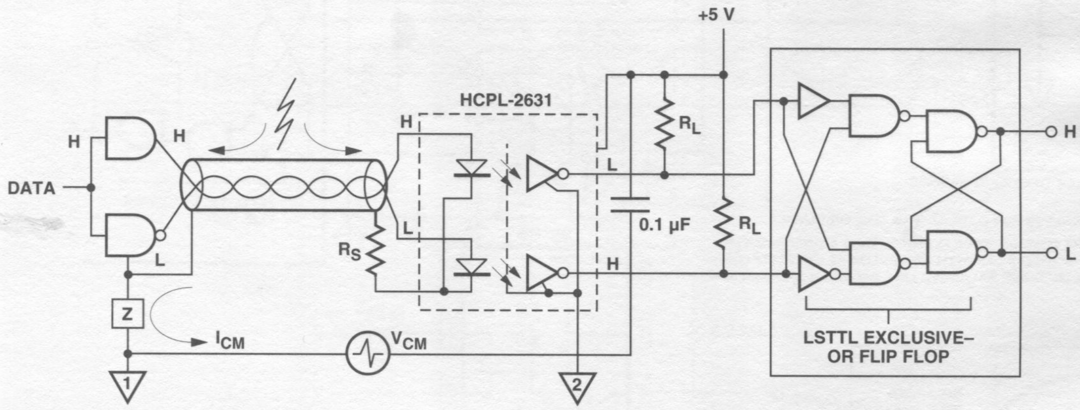
References

1) HCPL-2300 Low-Input Current High Speed Optocoupler
2) AN 947: Digital Data Transmission Using Optically-Coupler Isolators

Alternative HP Parts

HCPL-2602/12 High CMR Line Receiver

Isolated Balanced Line Receiver - Circuit No. 2



Description

This is a differential receiver using a dual-channel HCPL-2630 Optocoupler. The receiver circuit can handle data up to 10 Mbd for short line lengths. The capacitance of the twisted-pair wire introduces a propagation delay and, as a result, the data rate decreases with increasing line length. At the optocoupler output, an optional Exclusive-Or circuit can be used to increase CMR and to balance the propagation delays.

Performance of Circuit

- Signaling rate: up to 10 MBd
- Optocoupler common mode rejection: 10,000 V/µs

Benefits

- Dual channel optocoupler reduces boardspace
- Balanced circuit increases CMR performance thereby eliminating or reducing transient interference

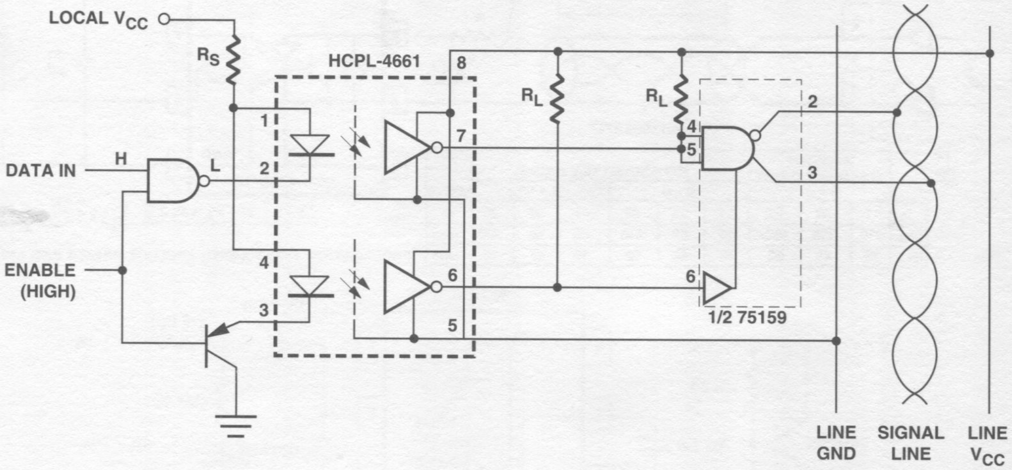
References

1) HCPL-2631 Dual High-Speed Optocoupler Technical Data
2) AN 947: Digital Data Transmission Using Optically-Coupler Isolators

Alternative HP Parts

1) HCPL-0631 Small Outline, Dual-Channel, High Speed Optocoupler
2) HCPL-4661 High-CMR, Dual-Channel Optocoupler
3) HCPL-56XX Hermetic High Speed Optocouplers

Isolated Tri-State Line Driver



Description

The above circuit converts a single-ended signal to a split-phase signal with a 75159 Tri-State Line Driver and dual-channel HCPL-4661 High CMR Optocoupler. When Input Enable goes low, the lower channel of the optocoupler operates the "strobe" input of the 75159 to make both outputs open.

Performance of Circuit

- Optocoupler signaling rate: up to 10 MBd
- Optocoupler CMR: 15,000 V/μs at 1000 V peak (typical)

Benefits

- Higher data rate than a current source pull-up
- High CMR performance reduces or eliminates transient noise

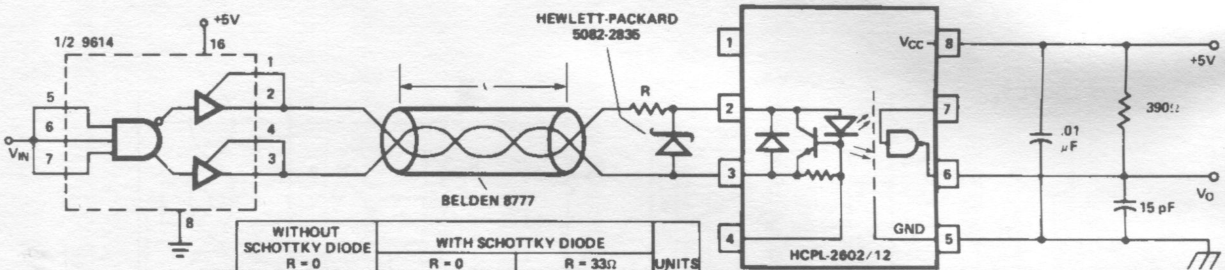
References

HCPL-4661 Dual Channel High CMR Optocoupler Technical Data

Alternative HP Parts

1) HCPL-2631 Dual Channel High Speed Optocoupler
2) HCPL-0631 Small Outline, Dual Channel Optocoupler
3) HCPL-56XX Hermetic High Speed Optocouplers

Isolated Unbalanced Line Receiver



	WITHOUT SCHOTTKY DIODE R = 0			WITH SCHOTTKY DIODE R = 0			WITH SCHOTTKY DIODE R = 33Ω			UNITS
ℓ	<1	30	90	<1	30	90	<1	30	90	m
t_{PHL}	210	365	450	50	80	235	50	70	200	nsec
t_{PLH}	35	45	60	35	45	60	35	45	60	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

Description

The above illustration is an unbalanced line receiver using the integrated voltage-clamp input optocoupler, HCPL-2602. The circuit is unbalanced because the termination impedance is different for both "ends" of the differential signal received by the HCPL-2602. TTL data is converted to a differential signal via the differential line driver 9614, and transmitted over twisted-pair wire. The Schottky diode helps to improve the turn-on and turn-off delays.

Performance of Circuit

- Signaling rate: up to 2 MBd at 90 m (up to 10 MBd with polarity non-reversing driver)
- Optocoupler common-mode transient rejection: 10,000 V/µs (typical)

Benefits

- Integrated line termination and voltage clamping saves board space
- Differential driver and optical isolated receiver reduce or eliminate transient noise interference

References

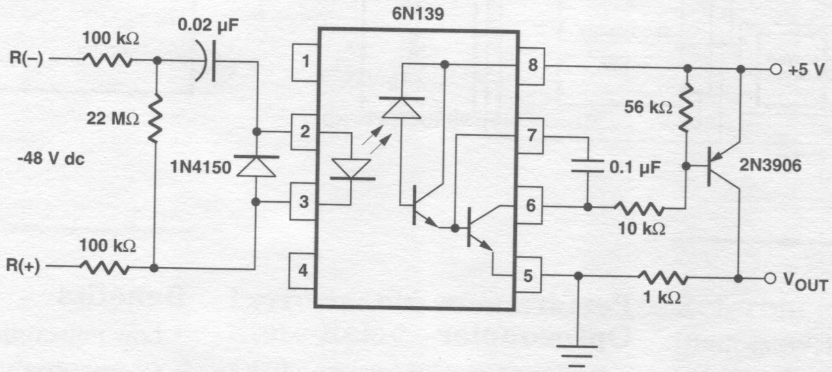
HCPL-2602/12 High CMR Line Receiver Optocoupler

Alternative HP Parts

1) HCPL-2601/31 High CMR, High Speed Optocoupler
2) HCPL-0601/0631 Small Outline, High Speed Optocoupler
3) HCNW2601 Widebody, High Speed Optocoupler

Telecommunications Applications

Telephone Ring Detection



Description

The 6N136 Low-Input Current Optocoupler is used to detect standard telephone ring signals. At the optocoupler output, a 0.1 µF base-collector capacitor provides a large enough Miller-capacitance so that a low-frequency ring signal (20 to 60 Hz) causes the output to remain low when ringing occurs.

Performance of Circuit

- Can detect 20 to 60 Hz, 30 to 80 V_{RMS} telephone ring signals

Benefits

- Simple and inexpensive circuit for ring signal detection
- Meets worldwide regulatory isolation standards

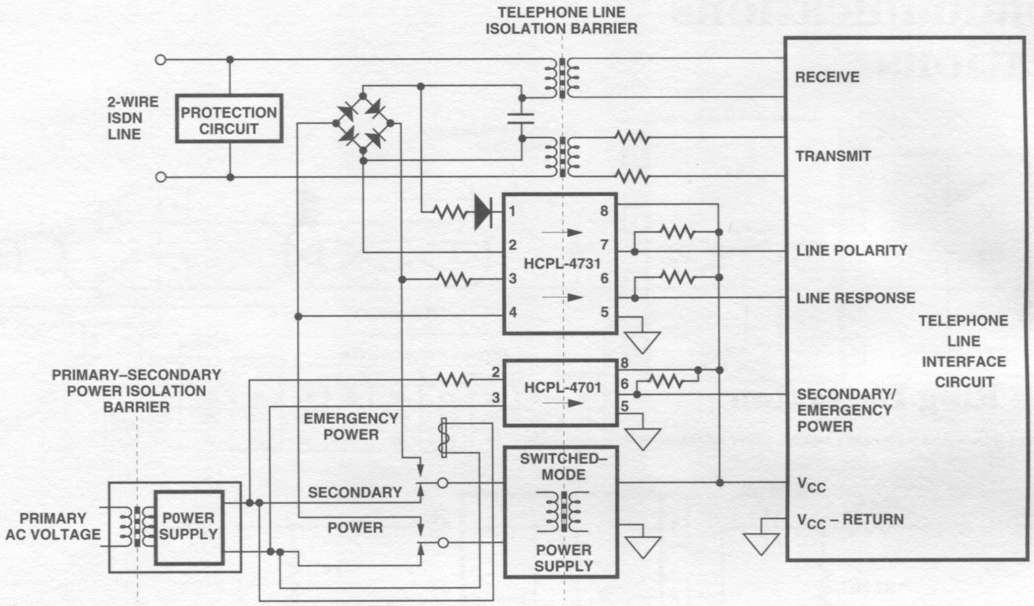
References

6N139 Low-Input Current Optocoupler Technical Data

Alternative HP Parts

1) HCPL-0700/1 Small Outline, Low-Input Current Optocoupler
2) HCPL-3700/60 Threshold Sensing Optocoupler
3) HCNW139 Low-Input Current Optocoupler

ISDN Interface



Description

The HCPL-4701 Low Power Optocoupler is suitable for standard telephone line interface functions such as: ring detection, line polarity, and power on/off detection. Integrated Services Digital Network (ISDN) applications severely restrict the input power that an optocoupler interface circuit can use, which makes the HCPL-4701 an ideal choice.

Performance of Optocoupler

- Input current for turn-on: 40 µA
- Typical total power dissipation with I_F = 40 µA: < 3 mW
- Typical propagation delay: 65 µs

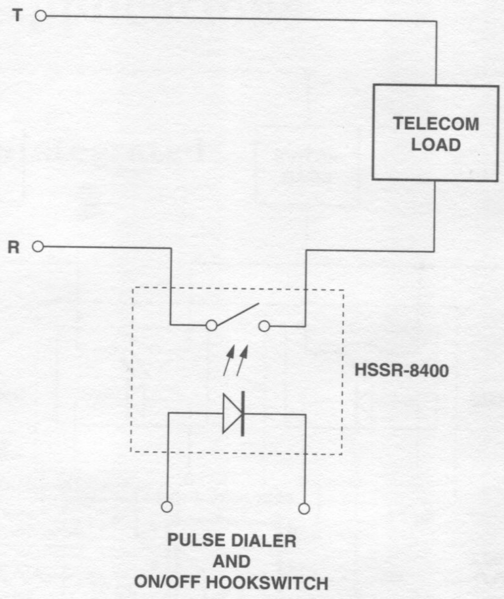
Benefits

- Low power dissipation
- Compatible with 3 V Logic

References

HCPL-4701 Lower Power Optocoupler Technical Data

Telephone Pulse Dialing and On/Off Hookswitch Circuit



Description

The HSSR-8400, optically coupled solid-state relay, can be used as an ON/OFF hookswitch and pulse dialer for telephone subscriber equipment such as modems and facsimile machines. The HSSR-8400's very low output on-resistance reduces signal distortion during voice transmission.

Performance of Solid-State Relay

- Solid-state relay withstand voltage: 400 V
- Typical solid-state relay on-resistance: 6 Ω
- Input turn-on current for solid-state relay: 5 mA

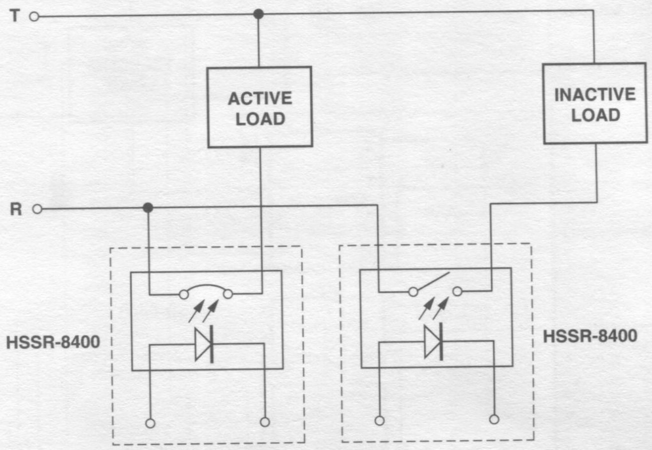
Benefits

- Greater reliability compared to electro-mechanical relays
- Compact size
- Low power dissipation

References

HSSR-8400 400 V Solid-State Relay

Telephone Line Selection Circuit



Description

Two HSSR-8400 optically coupled solid-state relays are used for selecting one of two telephone lines. One of the relays is turned on while the other is turned off. The HSSR-8400's very low output on-resistance reduces signal distortion during voice transmission. Telephone line selection circuits can be used in subscriber equipment such as computer modems and facsimile machines.

Performance of Circuit

- Solid-state relay withstand voltage: 400 V
- Typical solid-state relay on-resistance: 6 Ω
- Input turn-on current for solid-state relay: 5 mA

Benefits

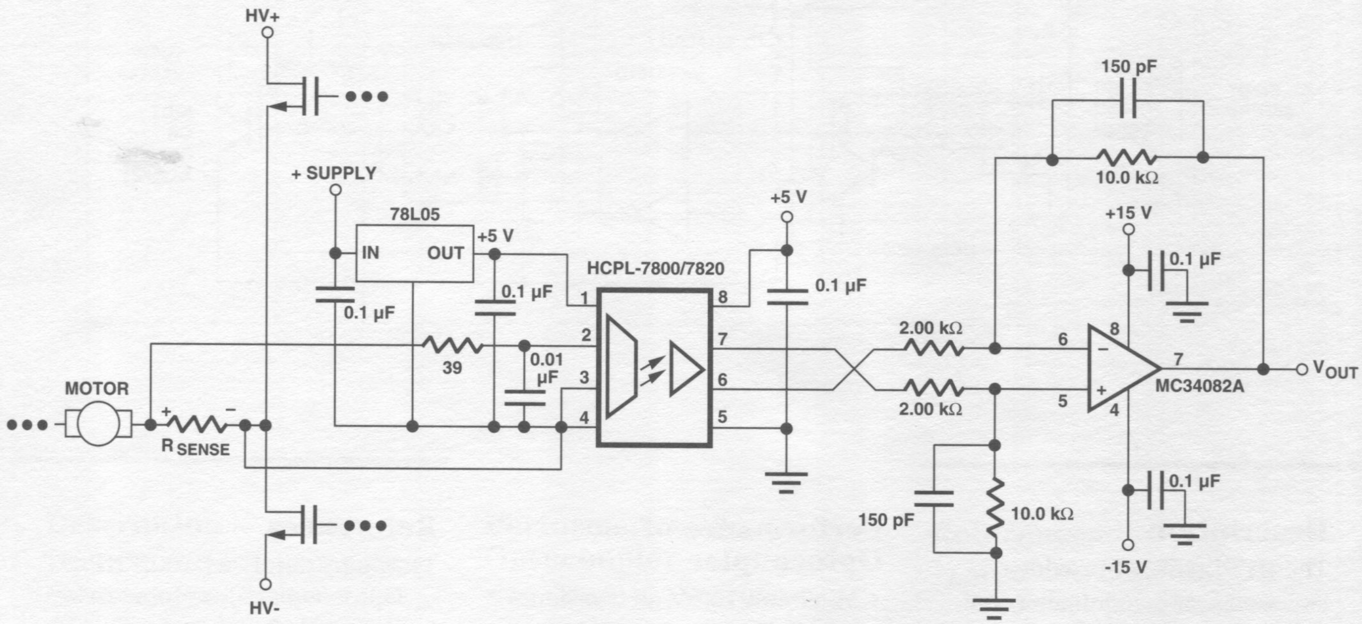
- Greater reliability compared to electro-mechanical relays
- Compact size
- Low power dissipation

References

HSSR-8400 400 V Solid-State Relay

Motor Control Applications

Motor Current Sensor/Integrated Isolation Amplifier



Description

The HCPL-7800/7820 Isolation Amplifiers can be used for isolating the motor current sensing element from the control circuit while at the same time transmitting precision analog signals. This circuit requires a high precision sensing resistor for monitoring the motor current. The voltage across the sensing resistor is fed to the HCPL-7800/7820 input pins 2 and 3. The sensing resistor is available from several suppliers, which are listed in the reference section below.

Performance of Circuit

- Can sense current up to 200 A or more
- Optocoupler bandwidth: Up to 200 kHz (HCPL-7820)
- Optocoupler nonlinearity: 0.05% (HCPL-7820)
- Optocoupler input offset voltage: 0.9 mV (typical)
- Optocoupler common-mode rejection:15 kV/µs

Benefits

- Small size and lower profile circuit compared to Hall-Effect device based current sensing circuits
- Easy availability of components required in this circuit
- High precision measurement while at the same time maintaining transient immunity

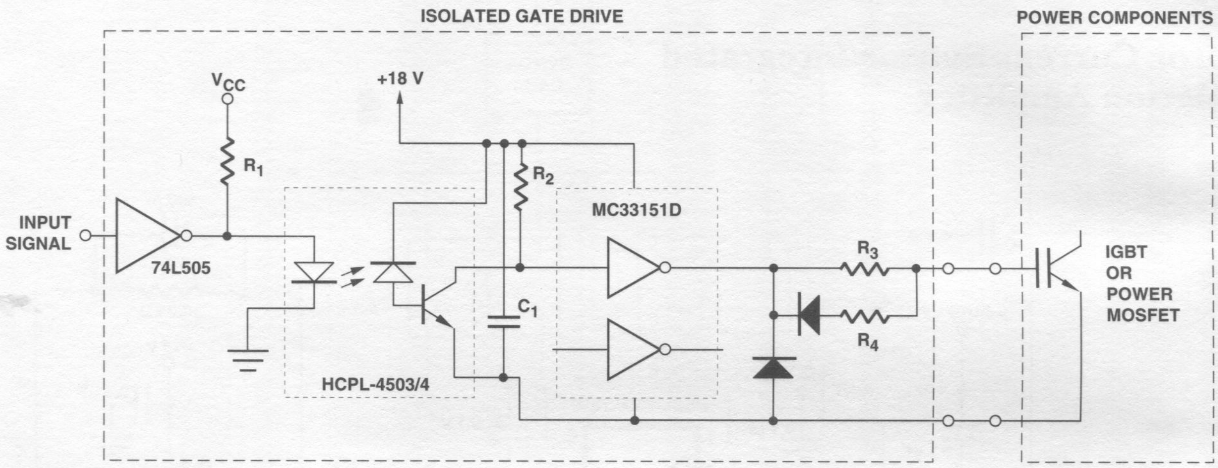
References

1) HCPL-7800/7820 Technical Data
2) HP Application Note AN 1059 and 1078, Isolation Amplifier design and applications
3) High precision current sensing resistor suppliers: Dale in USA; Isabellenhutte in Germany; and PCN in Japan

Alternative HP Parts

1) HCPL-7800A/B - Tighter gain tolerance version of HCPL-7800
2) CNR200/1 - General purpose analog optocoupler for building isolation amplifiers

Isolated Gate Driver for IGBT/MOSFET - Circuit No. 1



Description

The HCPL-4503/4 provides isolation for the controller that drives the power components (MOSFETs or IGBTs). The circuit provides full regulatory-approved isolation between the power and control circuits. The HCPL-4503/4 optocouplers can reject transients that have very high slew rates while at the same time transmit signals without much propagation delay.

Performance of Optocoupler

- Minimum 15 kV/μs transient immunity
- Typical propagation delay less than 1 μs
- Propagation delay difference between any two HCPL-4504 optocouplers: 0.9 μs or less

Benefits

- Avoids dangerous false turn-on in industrial environments
- Reduced total harmonic distortion for inverter ac output
- Reduced "Dead Time" for power transistor switching

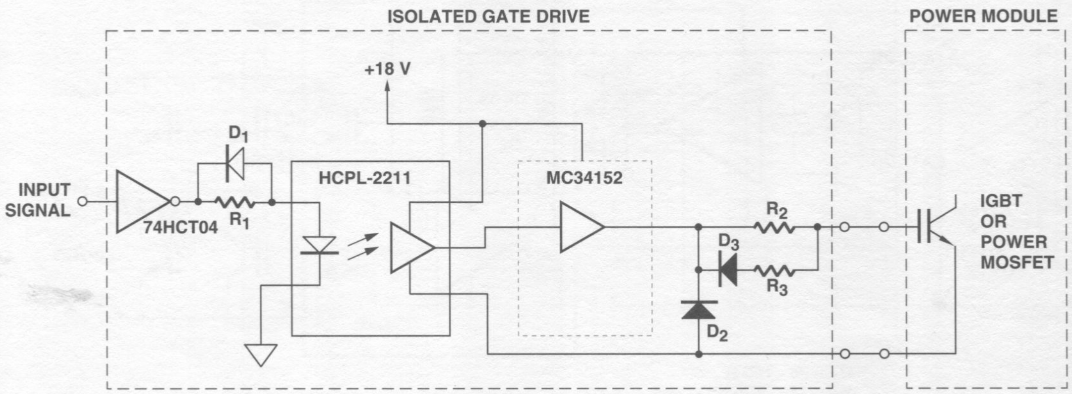
References

1) Application Brief 100, "HP Optocouplers for Motorola Power Module Interface"
2) HCPL-4503/4504 Technical Data

Alternative HP Parts

1) HCNW4503/4504 Widebody High-CMR Optocoupler
2) HCPL-0453/4, HCPL-M453/4 Small-Outline High-CMR Optocoupler
3) HCPL-3100/1 Gate Drive Optocoupler
4) HCPL-4506/0466 Gate Drive Interface Optocoupler
5) HCPL-52XX Hermetic High-CMR Optocoupler

Isolated Gate Driver for IGBT/ MOSFET - Circuit No. 2



Description

The HCPL-2211/2212 provides isolation for the controller that drives the power components (MOSFETs or IGBTs). This circuit provides full regulatory-approved isolation between the power and control circuits. The HCPL-2211/12 optocouplers can reject transients that have very high slew rates while at the same time transmit signals without much propagation delay.

Performance of Optocoupler

- Minimum 10 kV/µs transient immunity
- Typical optocoupler propagation delay: 150 ns
- CMOS drive circuit for optocoupler LED input

Benefits

- Avoids dangerous false turn-on in industrial environments
- Reduced total harmonic distortion for inverter ac output
- Reduced "Dead Time" for power transistor switching

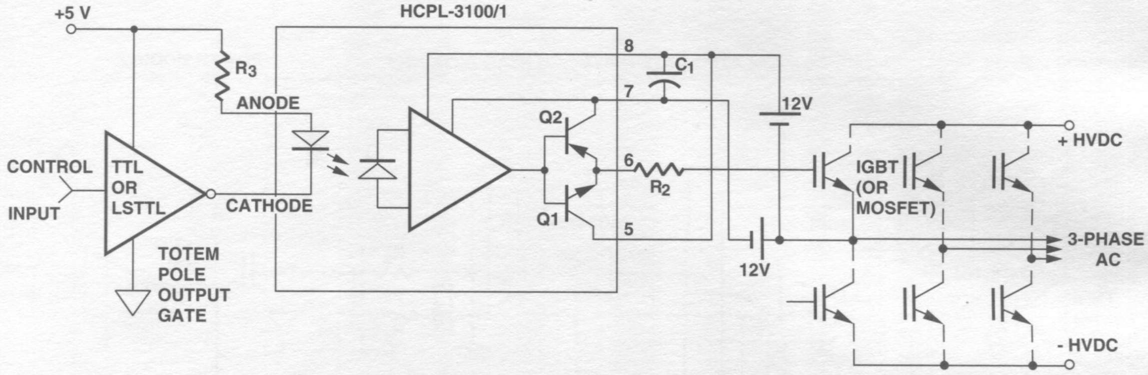
References

1) Application Brief 100, "HP Optocouplers for Motorola Power Module Interface"
2) HCPL-2211/12 Technical Data

Alternative HP Parts

1) CNW2211 Widebody High-CMR Optocoupler
2) HCPL-0211 Small-Outline High-CMR Optocoupler
3) HCPL-3100/1 Gate Drive Optocoupler
4) HCPL-4503/4 High-CMR Optocoupler
5) HCPL-4506/0466 Gate Drive Interface Optocoupler
6) HCPL-52XX Hermetic High-CMR Optocoupler

Isolated Gate Drive for IGBT/MOSFET - Circuit No. 3



R_2 = 25 - 100 Ω
R_3 = 180 Ω (HCPL-3100)
240 Ω (HCPL-3101)

BYPASS CAPACITOR C_1 = 0.1 µF

Description

This circuit uses the HCPL-3100/1 integrated base drive optocoupler for driving IGBTs and MOSFETs in a power inverter. The output interface for the HCPL-3100/1 requires only a few passive components for driving the base of an IGBT/MOSFET.

Performance of Optocoupler

- Gate drive current: 0.4 A peak, 0.1 A continuous
- Common-mode transient immunity: 5 kV/µs, 600 V peak
- Output power supply voltage: 15 to 35 V
- HCPL-3101 propagation delay: 0.5 µs

Benefits

- Fewer components
- Low propagation delay allows greater carrier frequency

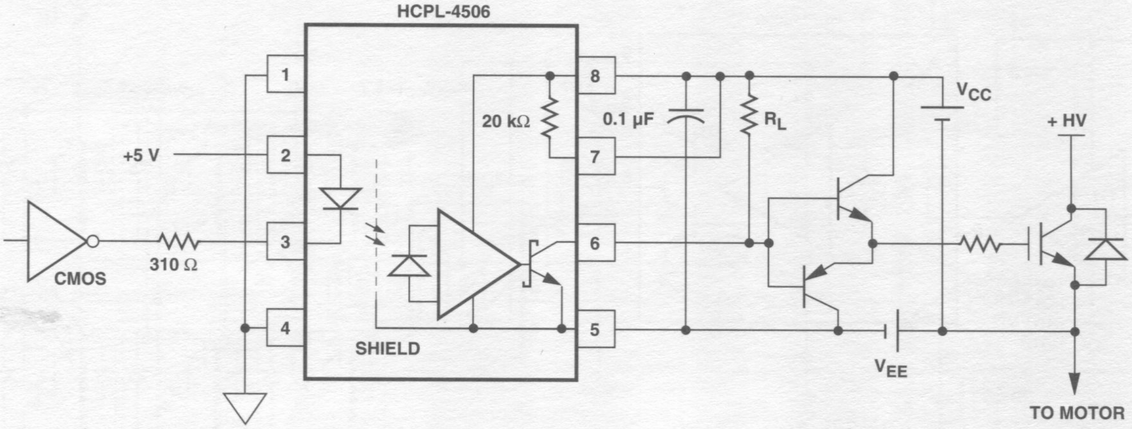
References

1) HCPL-3100/1 Technical Data
2) HP Application Note 1058, "Power Transistor Gate/Base Drive Optocouplers"

Alternative HP Parts

HCPL-4503 High CMR Optocoupler

Isolated Gate Drive for IGBT/ MOSFET - Circuit No. 4



Description

The HCPL-4506 optocoupler provides the isolation and level-shifting function for the controller that drives the power components (MOSFETs or IGBTs). With safety approvals from regulatory agencies, and guaranteed pulse-width distortion and propagation delay difference specifications, the HCPL-4506 can be the ideal choice in a variety of power-inverter circuits. The circuit designer can choose the appropriated push-pull transistor stage between the optocoupler and the power transistor.

Performance of Optocoupler

- Typical propagation delay with external pull-up resistor: 100 ns
- Guaranteed common-mode transient immunity: 15,000 V/µs at V_{PEAK} = 1,500 V
- Maximum propagation delay difference between any two optocouplers: 350 ns

Benefits

- Reduced dead time in the inverter output stage
- No erroneous turn-on of power transistor
- Reduced total harmonic distortion for inverter ac output

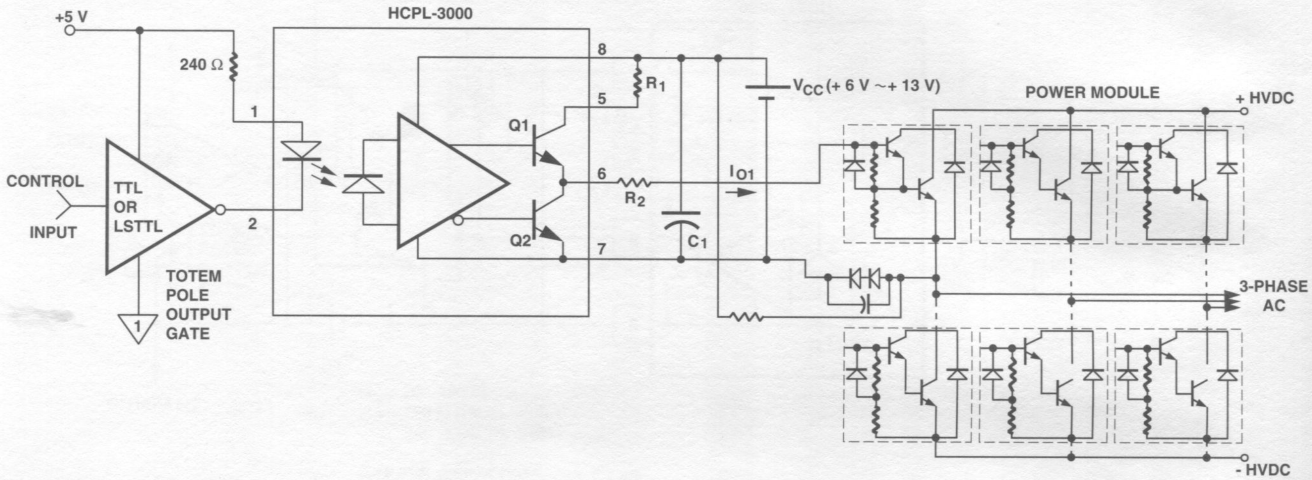
References

HCPL-4506 Gate Drive Optocoupler Technical Data

Alternative HP Parts

1) CNW4503/4 Widebody High-CMR Optocoupler
2) CNW2201 Widebody High-CMR, Low Input Current Optocoupler
3) HCPL-0466 Small Outline Gate Drive Optocoupler
4) HCPL-52XX Hermetic High Speed Optocouplers

Isolated Base Drive for Bipolar Power Transistors



Description

The HCPL-3000 Base Drive Optocoupler is used to drive bipolar power transistors in an H-Bridge inverter circuit. The HCPL-3000 contains an integrated base driver circuit at its output, which eliminates active components that may be otherwise required.

Performance of Optocoupler

- 1.0 A peak, 0.5 A continuous base drive current capability to the power transistor
- 1.5 kV/µs, 600 V peak common-mode transient immunity
- 2 µs propagation delay

Benefits

- Fewer components by eliminating buffer stage
- Low propagation delay gives capability for higher carrier frequency
- Cost-effective solution for consumer appliances

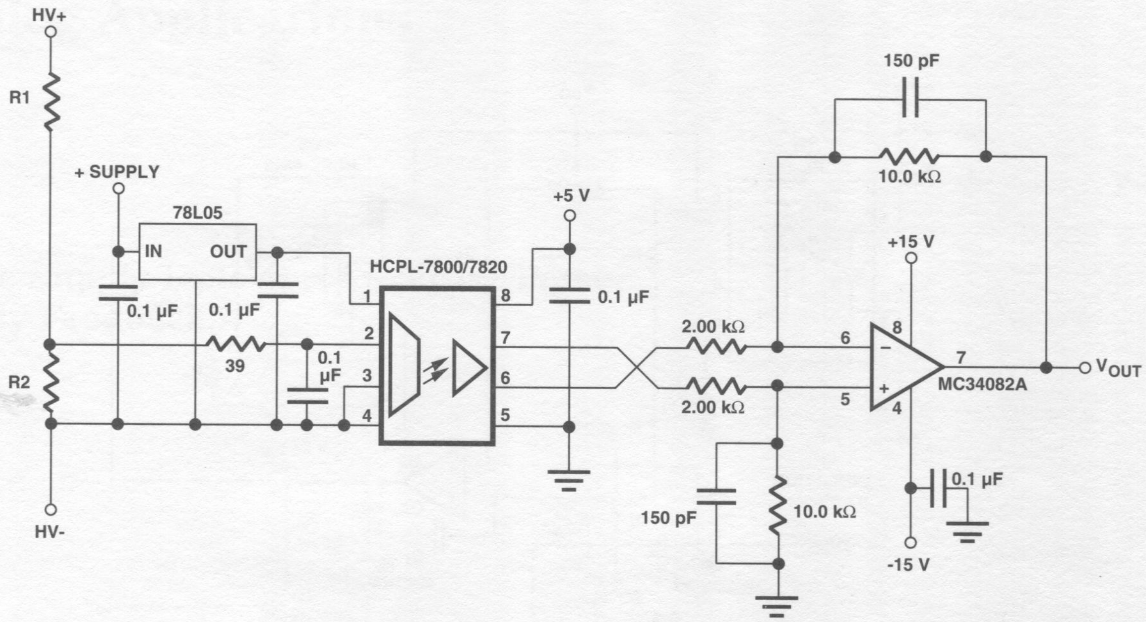
References

1) HCPL-3000 Technical Data
2) HP Application Note 1058, “Power Transistor Gate/Base Drive Optocouplers”

Alternative HP Parts

HCPL-4503 High CMR Optocoupler

Isolated High-Voltage Sensor - Circuit No. 1



Description

The HCPL-7800/7820 isolation amplifier can be used for sensing the rectified dc power supply voltage in a power inverter. The resistor divider network is used so that the full scale voltage at the HCPL-7800/7820 input is 200 mV. An isolated 5 V power supply is required to power the HCPL-7800/7820 input circuit.

Performance of Optocoupler

- 15 kV/µs transient rejection
- 0.05% nonlinearity (HCPL-7820)
- ± 1% gain tolerance (HCPL-7800A/B version)

Benefits

- Few components
- High electrical noise immunity

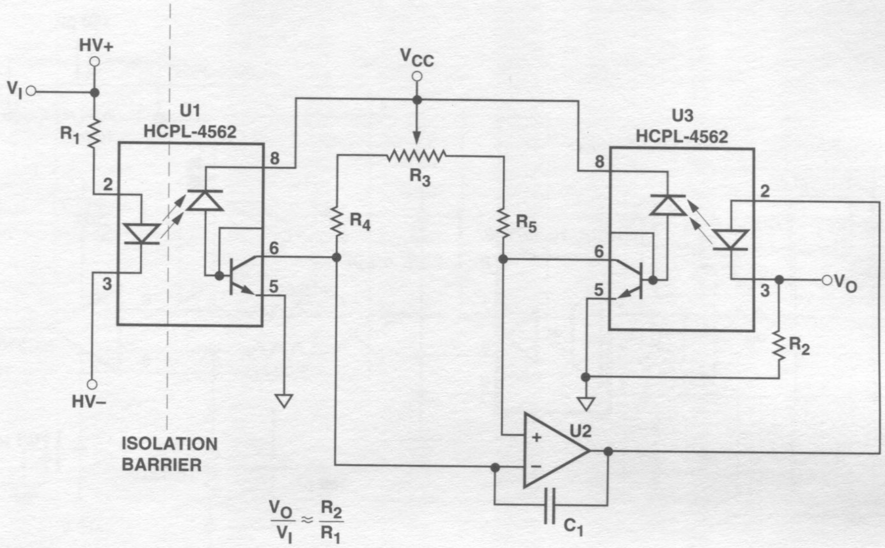
References

HCPL-7800/7820 Technical Data

Alternative HP Parts

HCPL-4562 Analog Optocoupler

Isolated High-Voltage Sensor - Circuit No. 2



Description

The HCPL-4562 Linear Optocoupler is used in a servo circuit to sense the rectified dc power supply voltage of a power inverter. The series resistor R_1 limits the current that drives the input LED of optocoupler U1. When the circuit is balanced with the potentiometer R_3, the output voltage V_0 is proportional to the high voltage dc power supply.

Performance of Optocoupler

- 122 dB isolation mode rejection ratio
- 0.25% nonlinearity

Benefits

- Simple circuit
- No isolated 5 V input power supply is required for optocoupler U1

References

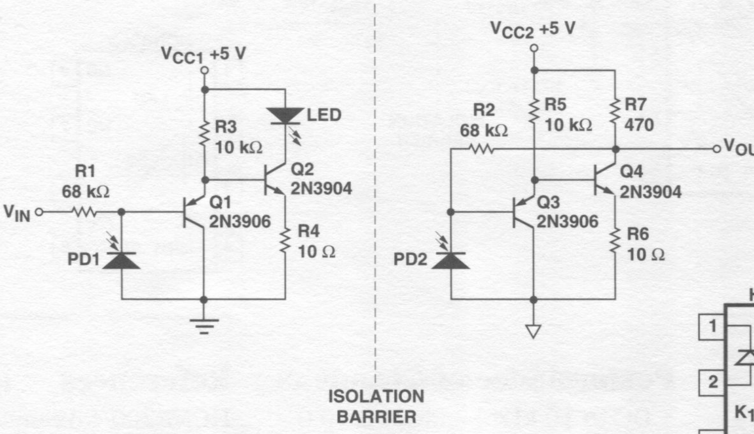
HCPL-4562 Technical Data

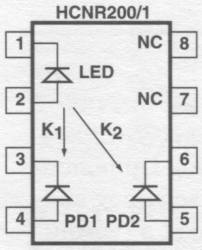
Alternative HP Parts

1) HCPL-7800/7820 Isolation Amplifier
2) HCNR200/1 Analog Optocoupler

Analog Applications

Single-Supply Isolation Amplifier/Power Supply Feedback





Description

This is a high-speed, low-cost isolation amplifier for use in the feedback path of switch-mode power supplies or in any analog signal isolation circuit. This circuit can be used in applications where high bandwidth, low-cost, and stable gain are required, but where accuracy is not critical.

Performance of Optocoupler

- 1.5 MHz bandwidth
- Stable gain
- Low-cost support circuit
- Circuit couples only positive voltage signals

Benefits

- Low cost solution for coupling positive voltage analog signals
- Simple way for sending power supply voltage feedback signal across isolation barrier

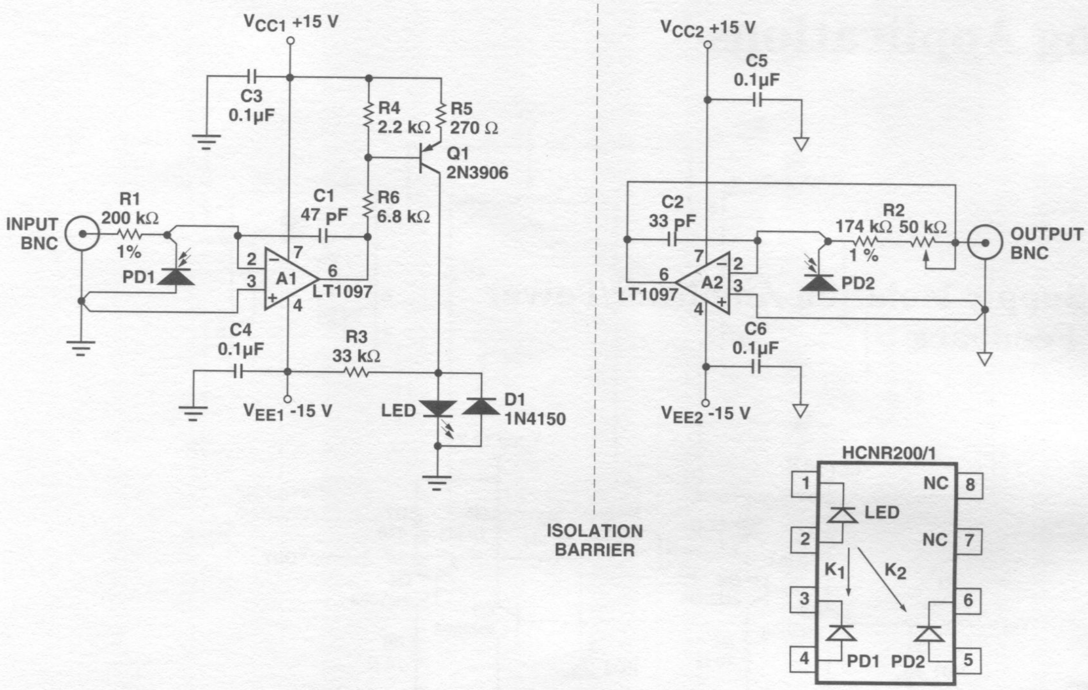
References

1) HCNR200/1 Technical Data
2) Solution Note 101, "Overview of HP's Optical Isolation Technology and Products for Motor Control Applications"

Alternative HP Parts

1) HCPL-7800/7820 Isolation Amplifier
2) HCPL-4562 Wideband Analog/Video Optocoupler

Precision Isolation Amplifier for Unipolar Signals



Description

This circuit uses the HCNR200/1 High-Linearity Analog Optocoupler to achieve high accuracy and wide dynamic range at a reasonable cost. This is accomplished by using low-cost, precision op-amps with very low input bias currents and offset voltages. The circuit couples only positive voltage analog signals.

Performance of Circuit

- DC to 10 kHz bandwidth
- Stable gain
- 0.1% nonlinearity
- 1 mV to 10 V input/output voltage range

Benefits

- Low-cost, high-accuracy solution for coupling analog signals
- Easy availability of support circuit components
- No offset adjustment is required

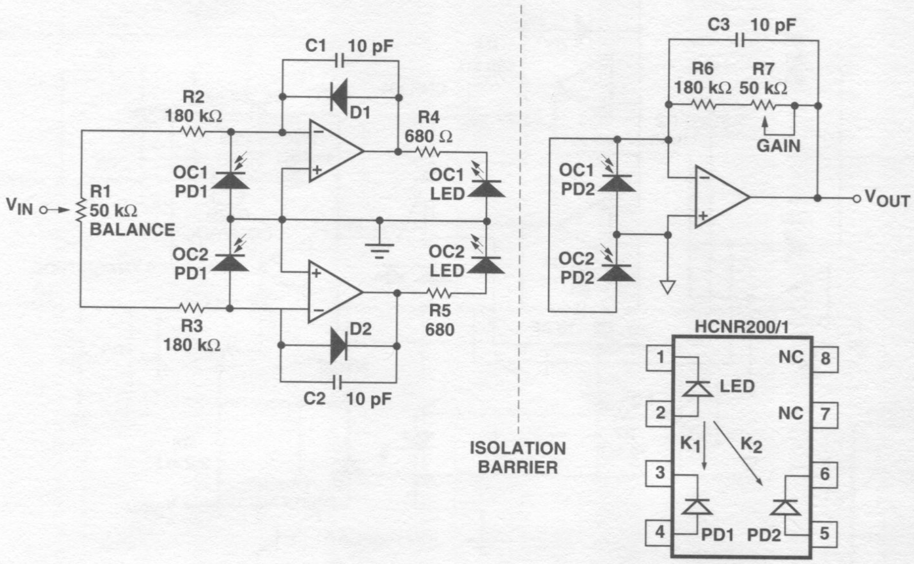
References

HCNR200/1 Technical Data

Alternative HP Parts

1) HCPL-7800/7820 Isolation Amplifier
2) HCPL-4562 Wideband Analog/ Video Optocoupler

Isolation Amplifier for Bipolar Signals - Circuit No. 1



Description

This circuit shows how the HCNR200 High Linearity Optocoupler can be used for transmitting bipolar analog signals across an isolation boundary. This circuit uses two optocouplers: OC1 and OC2; OC1 handles the positive portions of the input signal and OC2 handles the negative portions. Diodes D_1 and D_2 help reduce cross-over distortion by keeping both amplifiers active during both positive and negative portions of the input signal.

Performance of Circuit

- 0.01% nonlinearity
- Bandwidth: dc to 100 Hz
- Low transfer gain variation: ± 5% (K3 of HCNR201)

Benefits

- Low drift
- Low crossover distortion within the dc to 100 Hz frequency band
- Good linearity
- Very low offset

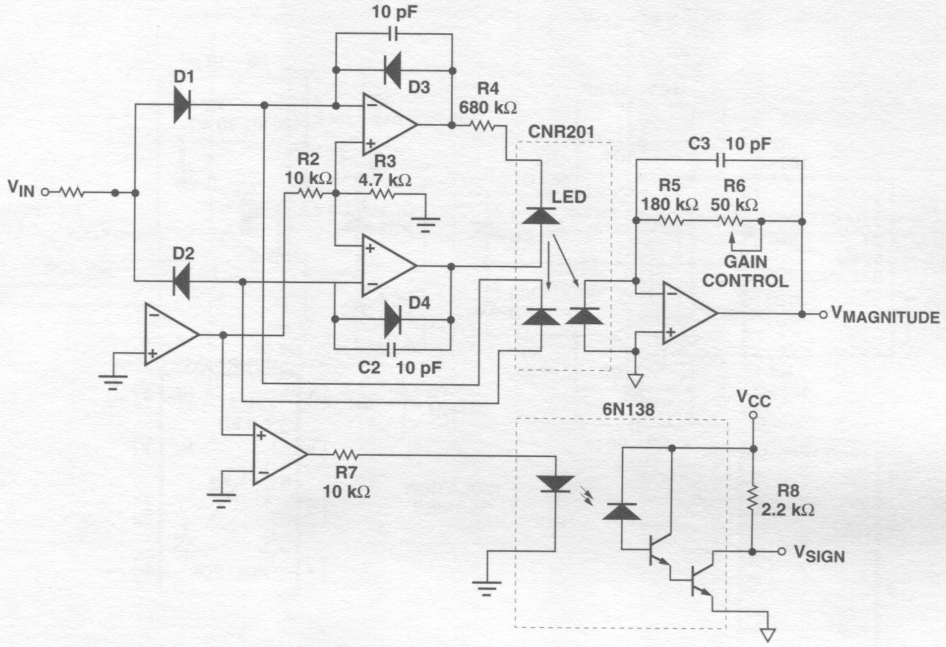
References

HCNR200/1 Technical Data

Alternative HP Parts

HCPL-7800/7820 Isolation Amplifier

Isolation Amplifier for Bipolar Signals - Circuit No. 2



Description

This circuit shows how bipolar analog signals can be transmitted across an isolation boundary by using just one HCNR200 optocoupler. This circuit provides an easy interface to A/D converters with two output signals: an analog signal proportional to the magnitude of the input signal, and a digital signal corresponding to the Sign of the input signal. The HCNW138 optocoupler, which couples the Sign signal, can be substituted with a faster optocoupler in case the Sign changes faster than 50 kHz.

Performance of Optocoupler

- 0.01% nonlinearity
- Wide bandwidth: dc to 1 MHz
- Low transfer gain variation: ± 5% (K3 of HCNR201)

Benefits

- Low drift
- Very low offset

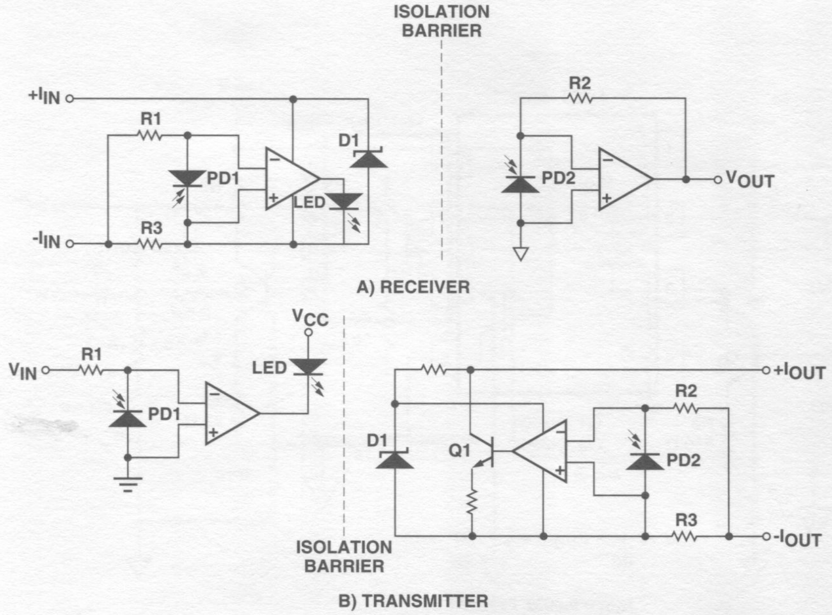
References

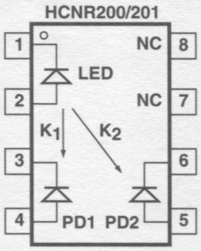
HCNR200/1 Technical Data

Alternative HP Parts

1) HCPL-7800 Isolation Amplifier
2) HCNW2601 High Speed Digital Optocoupler (for the Sign signal)

Isolated 4-20 mA Analog Current Loop Transmitter/Receiver





Description

The HCNR200/1 Analog Optocoupler isolates both the transmitter and receiver circuit from the 4 - 20 mA Analog Current Loop. One important feature of this circuit is that the loop side of the circuit is powered by the loop current. No isolated power supply is required.

Performance of Circuit

- Converts an analog voltage input to an analog current and vice versa
- HCNR200/1 nonlinearity: 0.1%
- HCNR201 gain tolerance: ± 5%

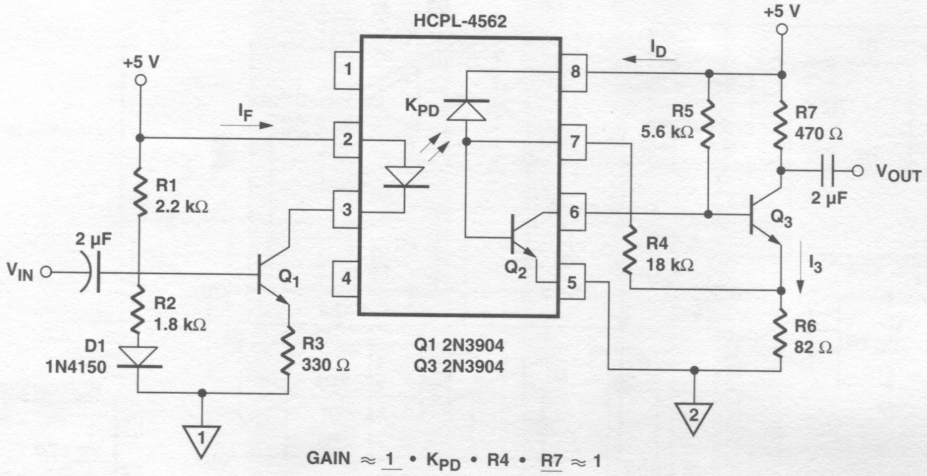
Benefits

- Low-cost simple circuit
- No isolated power supply needed on the 4 - 20 mA side of the circuit

References

HCNR200/1 Analog Optocoupler Technical Data

AC-Coupled Isolation Amplifier



$$\text{GAIN} \approx \frac{1}{R3} \cdot K_{PD} \cdot R4 \cdot \frac{R7}{R6} \approx 1$$

K_{PD} = 0.0032 TYPICALLY

Description

This circuit with the HCPL-4562 Wideband Analog/Video Optocoupler functions as an ac-coupled isolation amplifier that can be used for coupling audio or video signals. The input circuit biases the optocoupler LED at a quiescent current of about 6 mA, determined primarily by resistors R_1, R_2, and R_3. Diode D_1 helps to stabilize the operating point over the operating temperature range. An ac-coupled signal will modulate the collector current of transistor Q_1 and the optocoupler LED. The output circuit consists of a simple transresistance (current-in, voltage-out) amplifier followed by a common-emitter amplifier stage.

Performance of Circuit

- Typical bandwidth: 13 MHz
- Nominal gain of circuit: 1
- Isolation-mode rejection: 46 dB at 1 kHz
- Overall nonlinearity: 0.5%
- Optocoupler input current range: 4 mA-8 mA

Benefits

- Simple solution for coupling audio and video signals

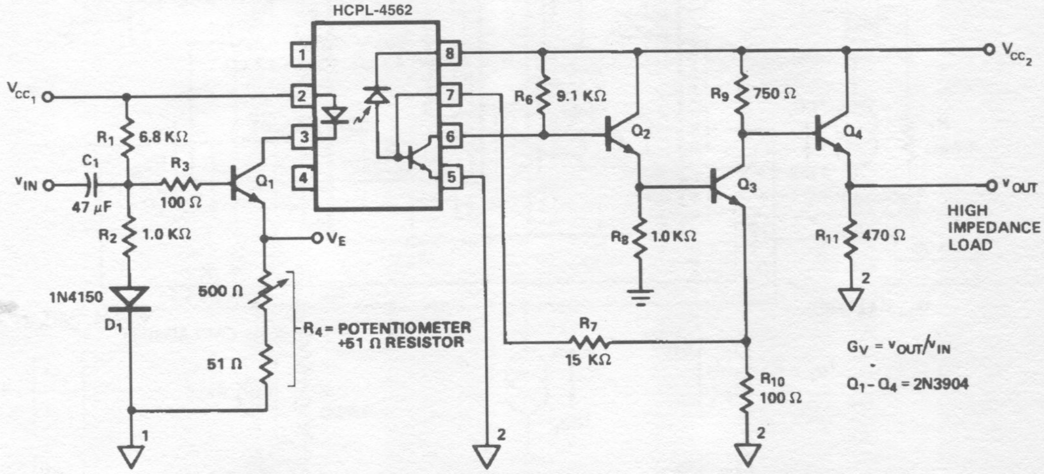
References

1) HCPL-4562 Wideband Analog/ Video Optocoupler Technical Data
2) Application Note 951-2, "Linear Applications of Optocouplers"

Alternative HP Parts

1) HCPL-2502, 6N135, 6N136 High Speed Transistor Output optocouplers
2) HCNW4562 Widebody Wide-band Analog/Video Optocoupler
3) HCPL-55XX, 4N55, HCPL-6530/1 Hermetic High Speed Optocoupler
4) HCPL-05XX Small-Outline High Speed Optocoupler

Isolated Video Interface



Description

This circuit, with the HCPL-4562 Wideband Analog/Video Optocoupler, is optimized for video signal coupling. The peaked response of the detector circuit helps extend the frequency range over which the gain is relatively constant. The number of gain stages, the overall circuit topology, and the dc bias points are all chosen to maximize the bandwidth.

Performance of Circuit

- Typical bandwidth: 15 MHz
- Typical Gain variation: -1.1 dB at 5 MHz with reference at 0.1 MHz
- Isolation Mode Rejection: 122 dB at 120 Hz

Benefits

- Cost-effective, high performance video interface circuit

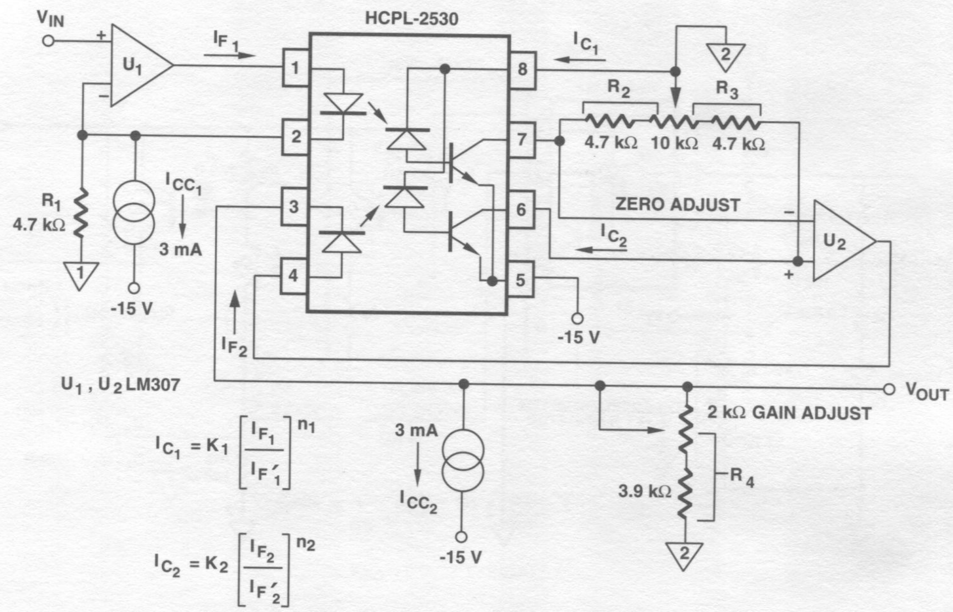
References

HCPL-4562 Wideband Analog/Video Optocoupler Technical Data

Alternative HP Parts

HCNW4562 Widebody Wideband Analog/Video Optocoupler

Differential DC Isolation Amplifier



Description

The above schematic uses a dual-channel, high-speed optocoupler (HCPL-2530/1) to function as a differential dc isolation amplifier. This circuit operates on the principle that an operating region exists where a gain increment of one optocoupler can be approximately balanced by the gain decrement of a second optocoupler.

Performance of Circuit

- 3% nonlinearity for 10 V peak-to-peak dynamic range
- Gain drift: -0.4%/°C
- Offset drift: ± 4 mV/°C
- 25 kHz bandwidth (limited by Op-Amps U1, U2, U3, and U4)

Benefits

- Simple coupling circuit for differential input analog signals

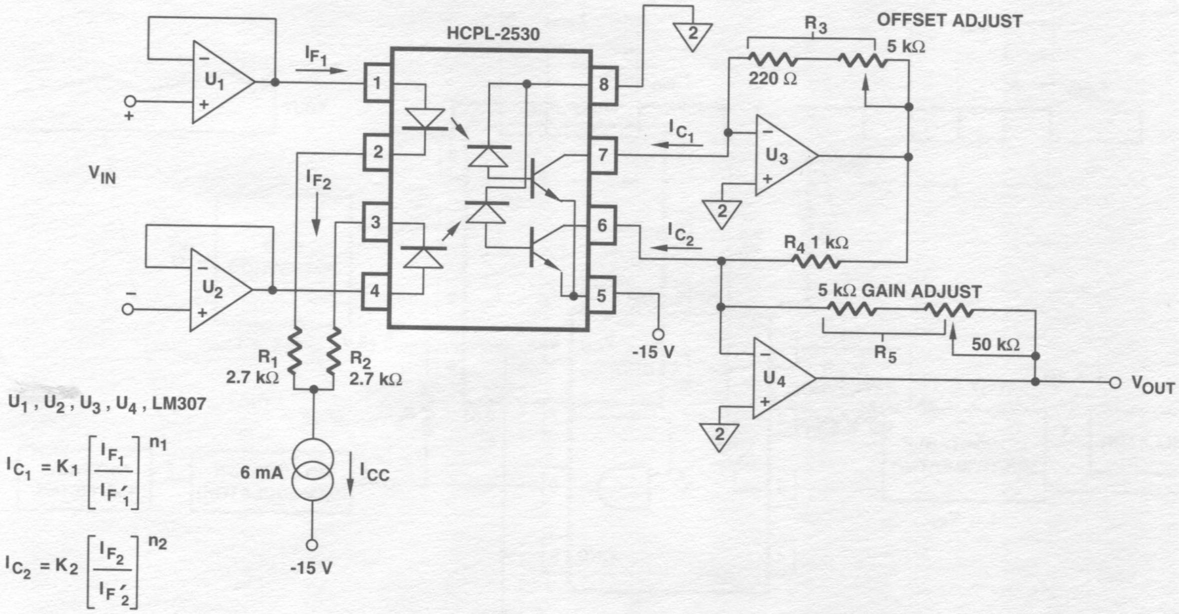
References

1) HCPL-2530/1 Dual Channel High Speed Optocoupler Technical Data
2) Application Note 951-2, "Linear Applications of Optocouplers"

Alternative HP Parts

1) HCPL-0530/1 Small-Outline Dual Channel High Speed Optocoupler
2) HCPL-5530/1, HCPL-6530/1 Hermetic Dual Channel High Speed Optocoupler

Servo Type DC Isolation Amplifier



Description

The above schematic uses a dual-channel, high-speed optocoupler (HCPL-2530/1) to function as a servo type dc isolation amplifier. This circuit operates on the principle that two optocouplers will track each other if their gain changes by the same amount over a specific operating region.

Performance of Circuit

- 1% linearity for 10 V peak-to-peak dynamic range
- Gain drift: -0.03%/°C
- Offset Drift: ± 1 mV/°C
- 25 kHz bandwidth (limited by Op-Amps U1, U2)

Benefits

- Simple coupling circuit for analog signals

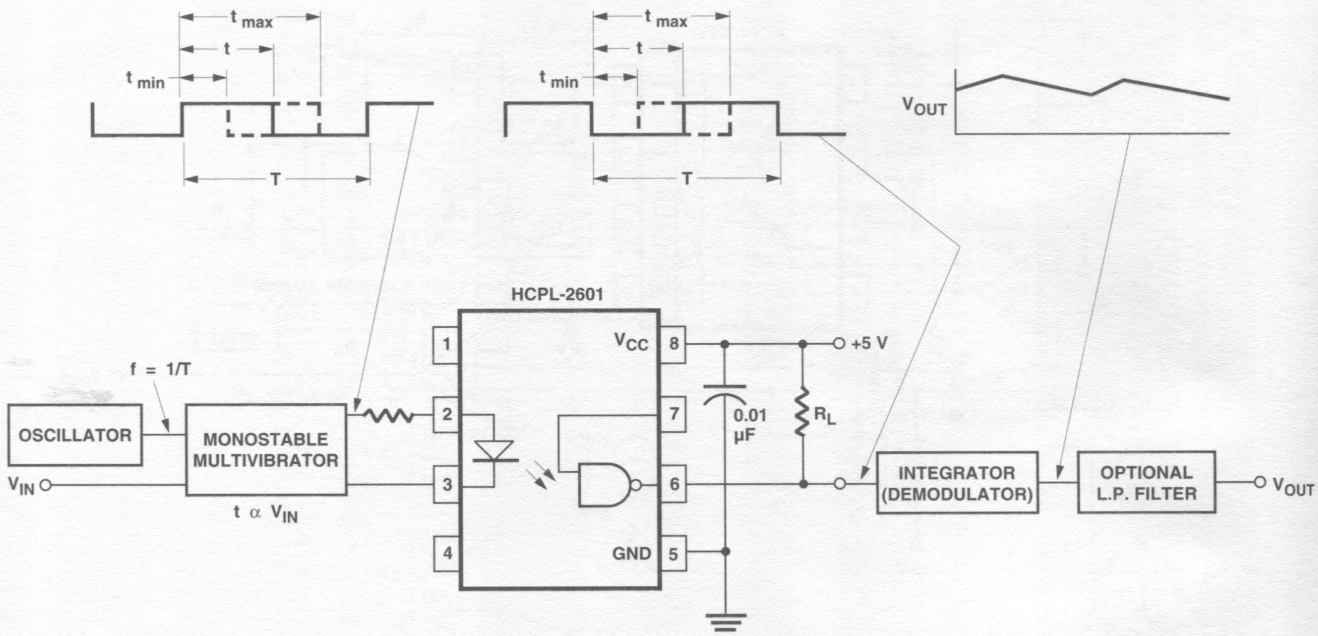
References

1) HCPL-2530/1 Dual Channel High Speed Optocoupler Technical Data
2) Application Note 951-2, "Linear Applications of Optocouplers"

Alternative HP Parts

1) HCPL-0530/1 Small-Outline Dual Channel High Speed Optocoupler
2) HCPL-5530/1, HCPL-6530/1 Hermetic Dual Channel High Speed Optocoupler

Analog Signal Coupling Using Pulse-Width Modulation



Description

Pulse-width modulation is a digital conversion technique for transmitting analog signals between two isolated systems. The above schematic shows an oscillator and a monostable multivibrator combination which generates digital pulses whose widths are proportional to the analog input. The digital pulses are supplied to the input of HCPL-2601 High Speed Digital Optocoupler. At the output of the optocoupler, an integrator and low-pass filter circuit converts the pulse-width modulated signal back to the original analog signal.

Performance of Circuit

- Maximum pulse-width distortion (PWD) of HCPL-2601: 35 ns
- Signal bandwidth: limited by linearity of analog circuit and PWD of HCPL-2601

Benefits

- Digital techniques allow greater control of accuracy of the analog signal

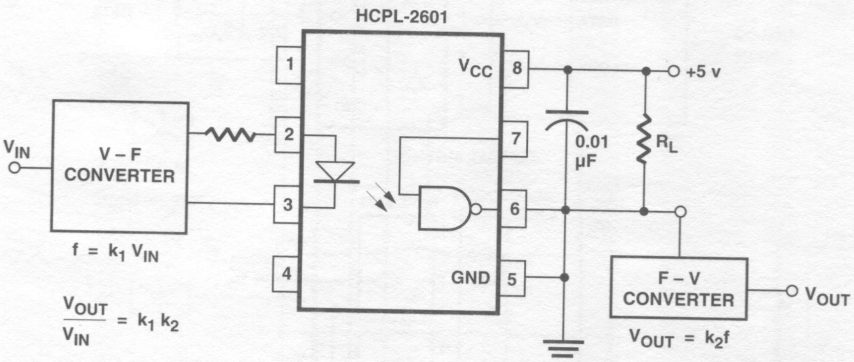
References

1) HCPL-2601 High Speed Digital Optocoupler Technical Data
2) HP Application Note 951-2, "Linear applications of Optocouplers"

Alternative HP Parts

1) HCNW2601 Widebody High Speed Digital Optocoupler
2) HCPL-0601 Small-Outline High Speed Digital Optocoupler
3) HCPL-5601 Hermetic High Speed Digital Optocoupler
4) HCPL-7101 50 MBd CMOS Optocoupler

Analog Signal Coupling Using Voltage-to-Frequency Conversion



Description

Voltage-to-frequency conversion is one technique for transmitting analog signals between two isolated systems. The above schematic shows an analog signal, V_{IN}, converted into a frequency that is proportional to the analog value of V_{IN}. The variable frequency signal is then coupled through by the HCPL-2601 High Speed Digital Optocoupler. At the optocoupler output, the variable frequency is converted back to an analog signal with a frequency-to-voltage converter. The operating frequency for this circuit is up to 5 MHz, however, for higher frequency operation up to 25 MHz, the HCPL-7101 optocoupler may be used.

Performance of Circuit

- Maximum pulse-width distortion (PWD) of HCPL-2601: 35 ns
- Signal bandwidth: limited by bandwidth of analog circuit and PWD of HCPL-2601

Benefits

- High speed digital techniques allows large bandwidth analog signals
- Nonlinearity of optocoupler is a not a design issue

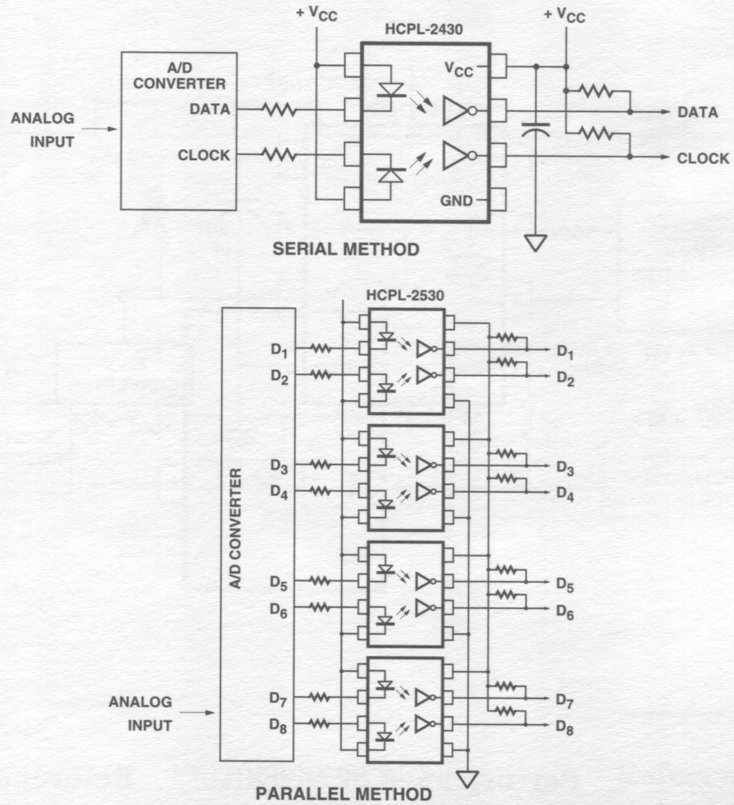
References

1) HCPL-2601 High Speed Digital Optocoupler Technical Data
2) HP Application Note 951-2, "Linear applications of Optocouplers"

Alternative HP Parts

1) HCNW2601 Widebody High Speed Digital Optocoupler
2) HCPL-0601 Small-Outline High Speed Digital Optocouple
3) HCPL-5601 Hermetic High Speed Digital Optocoupler
4) HCPL-7101 50 MBd CMOS Optocoupler

Analog Signal Coupling Using A/D Converters



Description

When better linearity and high temperature stability are required, digital techniques can be used to couple analog signals. This technique is especially recommended when an analog signal will eventually be processed or recorded digitally. The above schematic shows two ways of sending A/D output signals: in serial or in parallel.

Performance of Circuit

- Maximum pulse-width distortion (PWD) of HCPL-2431: 25 ns
- Maximum propagation delay skew of HCPL-2431: 35 ns

Benefits

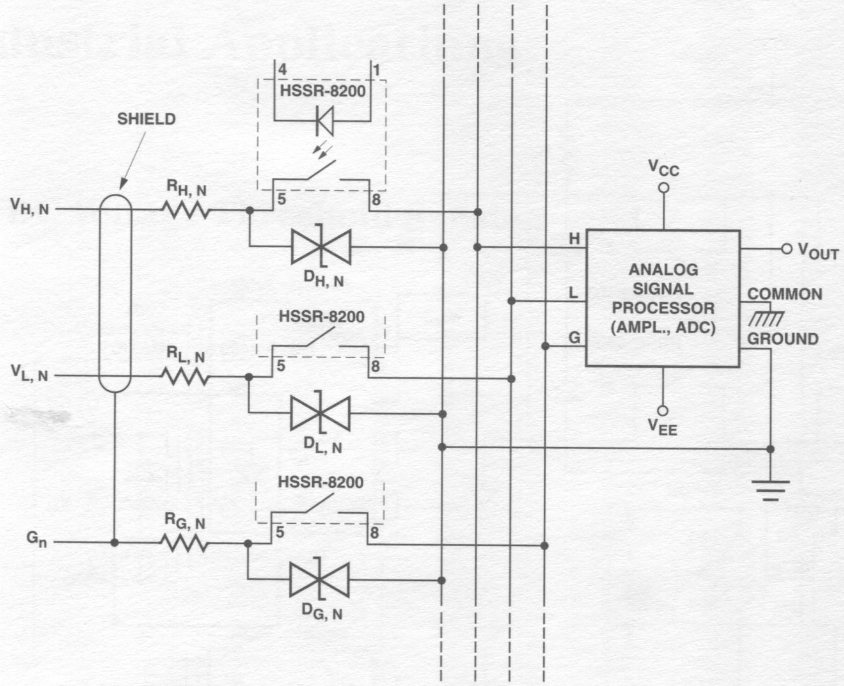
- Digital techniques allow greater resolution and large bandwidth
- Nonlinearity of optocoupler is a not design issue

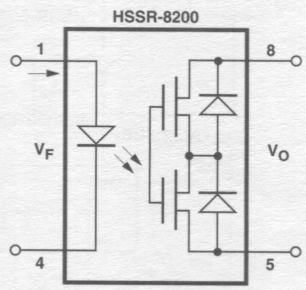
References

1) HCPL-2430 High Speed Digital Optocoupler Technical Data
2) HCPL-2530 High Speed Optocoupler Technical Data
3) HP Application Note 951-2, "Linear applications of Optocouplers"

Alternative HP Parts

1) HCPL-0631 Small-Outline High Speed Digital Optocoupler
2) HCPL-0531 Small-Outline High Speed Optocoupler
3) HCPL-5431 Hermetic High Speed Digital Optocoupler
4) HCPL-5531 Hermetic High Speed Optocoupler





Description

The HSSR-8200 Solid State Relay (SSR) can be used for multiplexing one set of analog inputs from several. In the above circuit, the selected analog input is presented to a signal processor. The differential inputs (H and L) are shielded by a guard (G) driven by the processor. When open, the contacts of the HSSR-8200 can withstand 200 V, positive or negative. Protection against damage due to exceeding 200 V is provided by the metal-oxide varistors $D_{H,N}$, $D_{L,N}$, and $D_{G,N}$.

Performance of Solid State Relay

- Output leakage current: 20 pA (typical) at $V_O = 200$ V
- Turn-on current: 1 mA
- Output capacitance: 4.5 pF (maximum)
- Output offset voltage: 0.2 µV (typical)

Benefits of Solid State Relay

- High output off-impedance and low offset voltage allows high accuracy measurement
- Small size lower power dissipation

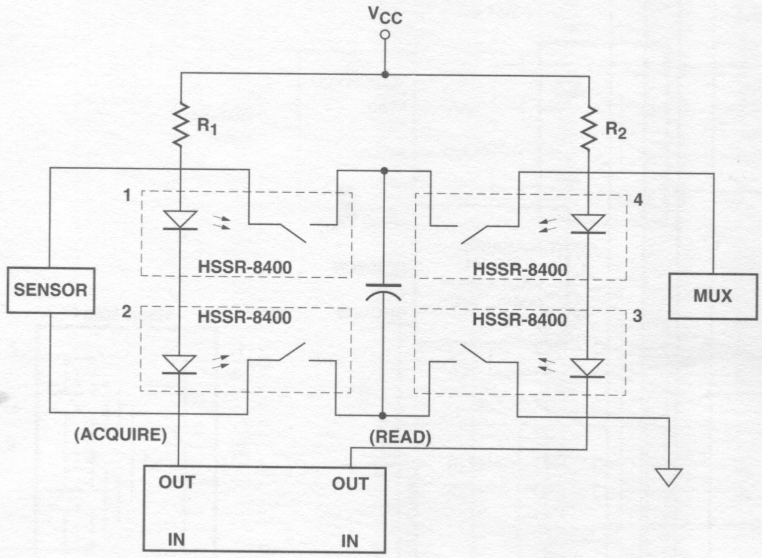
References

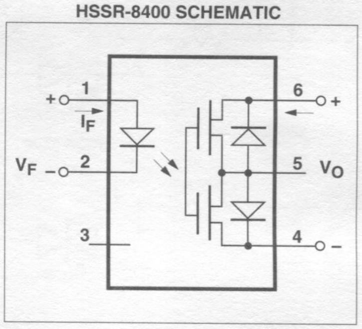
1) HSSR-8200 Solid State Relay Technical Data
2) Application Note: Small Signal Solid State Relay

Alternative HP Parts

1) HSSR-8400: 400 V Solid State Relay
2) HSSR-7100 Hermetic Solid State Relay

Analog Signal Sensing - Flying Capacitor Technique





Description

The HSSR-8400 optically-coupled, solid-state relay (SSR) can be used for measuring voltages on industrial sensors such as thermocouples. When SSRs 1 and 2 are closed, the voltage is acquired from the sensor and stored across the capacitor. After SSRs 1 and 2 open and SSRs 3 and 4 close, the voltage across the capacitor is read by the multiplexer.

Performance of Solid State Relay

- Output withstand voltage: 400 V
- Typical output leakage current: 0.6 nA at $V_O = 400$ V
- Typical SSR switching time: turn-on time = 0.5 µs; turn-off time = 0.013 µs

Benefits of Solid State Relay

- Greater reliability compared to electro-mechanical relays
- Compact size
- Lower power dissipation

References

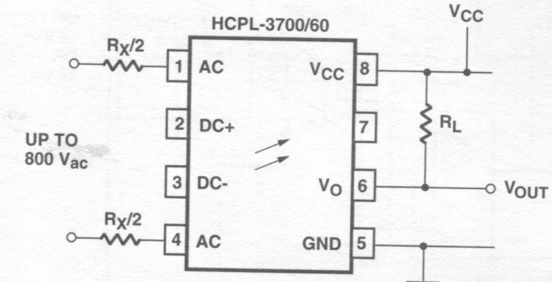
HSSR-8400 Solid State Relay Technical Data

Alternative HP Parts

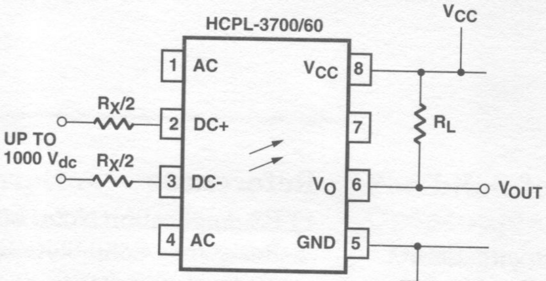
HSSR-8200 - 200 V Solid State Relay

Industrial Applications

AC/DC Voltage Threshold Sensing

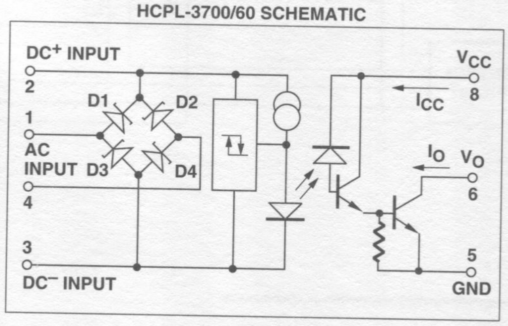


AC INPUT CONFIGURATION



DC INPUT CONFIGURATION

HCPL-3700/60 SCHEMATIC



Description

The HCPL-3700/60 Threshold-Sensing Optocoupler can be used for sensing the ac/dc power on/off condition. At the optocoupler input, only a pair of series resistors $R_X/2$ are required to limit the current. The ac signal can be filtered with a capacitor at either the input or the output of the optocoupler. For more information refer to HP Application Note AN 1004, "Threshold Sensing for Industrial Control Systems." The value of R_X determines the threshold sensing voltage.

Performance of Circuit

- HCPL-3760 optocoupler threshold input current: 1.3 mA (typical)
- Typical optocoupler propagation delay: 10 µs
- Optocoupler common mode transient immunity: 600 V/µs (typical)
- Maximum input voltage: up to 1000 Vdc, or 800 Vac

Benefits

- HCPL 3700/60's built-in diode bridge and hysteresis circuit reduces component count
- HCPL-3760's low threshold sensing current reduces power dissipation
- Threshold voltage can be adjusted by external resistor R_X

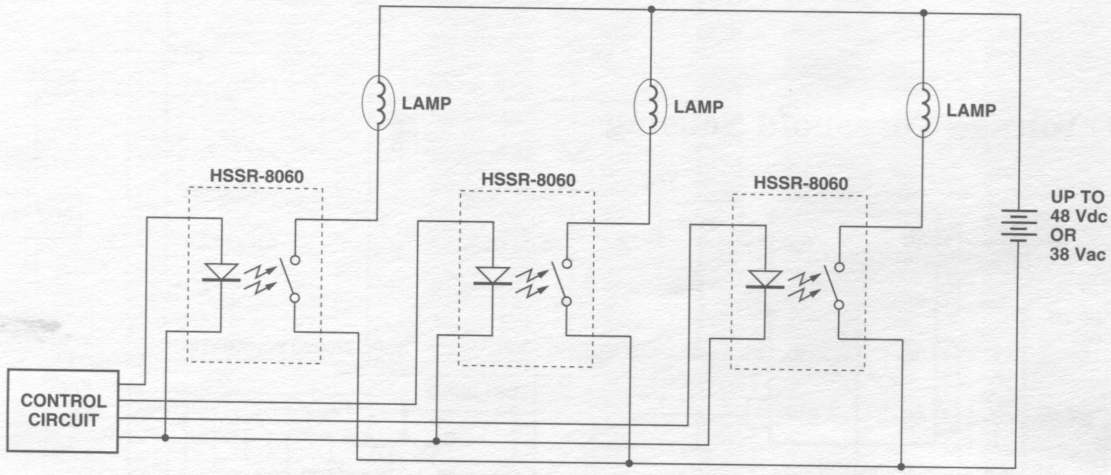
References

1) HP Application Note AN 1004, "Threshold Sensing for Industrial Control Systems"
2) HCPL-3700/60 Threshold Sensing Optocoupler Technical Data

Alternative HP Parts

HCPL-57XX: Hermetic Threshold Sensing Optocoupler

Low Power - AC/DC Industrial Switching



Description

The HSSR-8060 Solid State Relay (SSR) can be used for switching low-voltage incandescent lamps in industrial equipment. This SSR can be controlled with TTL or CMOS 5V logic, and requires only 5 mA for turn-on. For dc switching, the HSSR-8060 output can pass up to 1.5 A steady-state current, and 7.0 A transient current.

Performance of Solid State Relay

- Maximum output withstand voltage: 60 V peak, either polarity
- Typical output on-resistance: 0.4 Ω for ac connection; 0.1 Ω for dc connection (refer to HSSR-8060 Solid-State Relay Technical Data for an explanation of ac and dc connections.)
- Maximum output steady state current: 1.5 A for dc connection; 0.75 A for ac connection

Benefits

- Greater reliability compared to electro-mechanical relays
- Compact size
- With a low input turn-on current of 5 mA and low output on-resistance there is less power dissipation

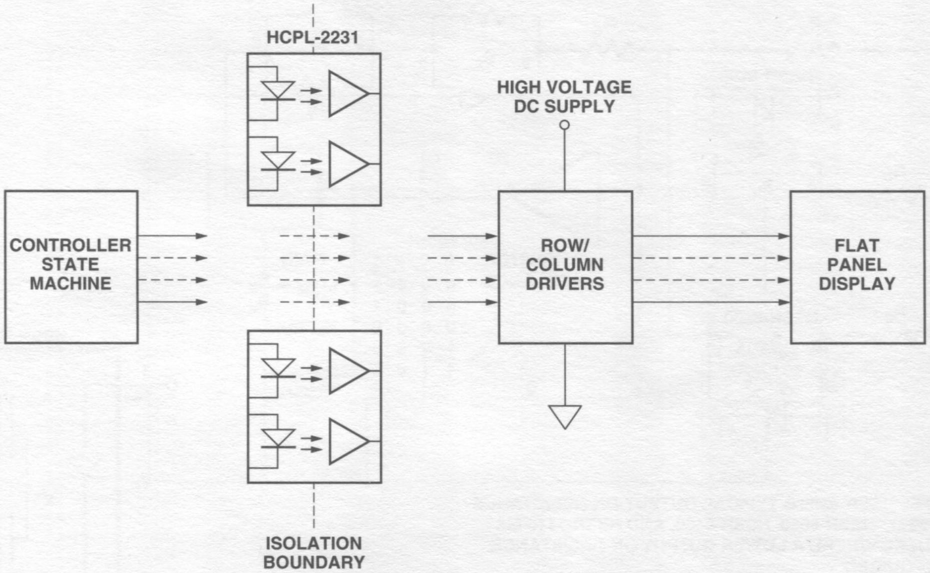
References

1) HP Application Note, Low On-Resistance Solid State Relays
2) HSSR-8060 Solid-State Relay Technical Data

Alternative HP Parts

1) HSSR-7110/1 Hermetic Solid State Relay
2) HSSR-8400, 400 V Solid-State Relay

Optical Isolation In Flat-Panel Displays



Description

The HCPL-2231 dual-channel, high-speed, optocoupler isolates the low-voltage logic circuit from the high-voltage Flat-Panel Display row/column drivers. Examples of Flat-Panel Display technologies requiring such high voltage technologies are Electro-Luminescence, Fluorescence, and Plasma technologies. The optocoupler serves the functions of level shifting and safety isolation.

Performance of Optocoupler

- Maximum propagation delay time: 300 ns
- Input turn-on current: 1.6 mA
- Common-mode transient rejection: 10,000 V/μs at 1000 V peak for the HCPL-2232

Benefits of Optocoupler

- Compact size and easy interface compared to pulse transformers
- Low input current allowing CMOS interface
- Low component count (HCPL-2231/2 requires no pull-up resistor)

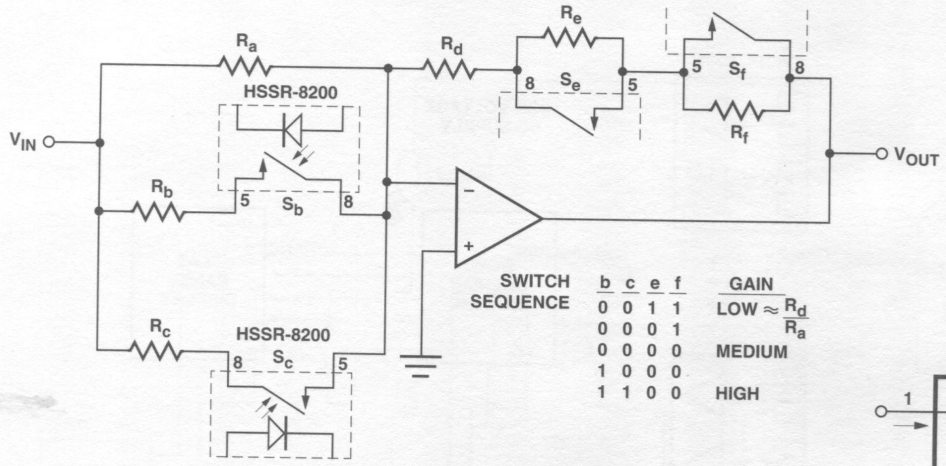
References

HCPL-2231/2 Low Input Current Optocoupler Technical Data

Alternative HP Parts

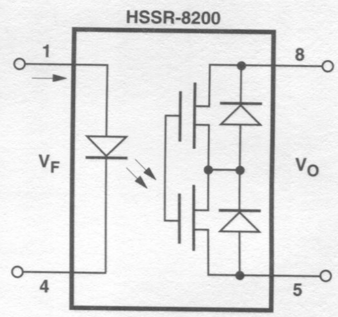
1) HCPL-0201/11 Small Outline Low Input Current Optocoupler
2) HCPL-52XX series Hermetic, Low Input Current Optocoupler
3) HCNW-2201/11 Widebody Low Input Current Optocoupler
4) HCPL-2430/1 20 MBd Logic-Gate Optocoupler
5) HCPL-7101 50 MBd CMOS Logic Optocoupler

Gain Selection for Op-Amp Circuits



SWITCH SEQUENCE	b	c	e	f	GAIN
	0	0	1	1	LOW $\approx \frac{R_d}{R_a}$
	0	0	0	1	
	0	0	0	0	MEDIUM
	1	0	0	0	
	1	1	0	0	HIGH

NOTE: HSSR-8200'S TYPICAL OUTPUT ON-RESISTANCE IS 125 Ω. HSSR-8060, HSSR-8400, AND HSSR-7110 MAY BE USED WHERE A LOWER OUTPUT ON-RESISTANCE IS REQUIRED.



Description

The above circuit shows how the HSSR-8200 Solid State Relay can be used for gain selection in an operational amplifier circuit. The HSSR-8200's low offset and negligible non-linearity when the output is closed ensures a low error over a four-decade range. A similar scheme with the HSSR-8200 can be used for gain selection in a non-inverting amplifier.

Performance of Solid-State Relay

- Typical output offset voltage: 0.2 μV with I_F = 1 mA
- Typical output on-resistance: 125 Ω
- Typical output off-impedance: 10,000 GΩ

Benefits of Solid-State Relay

- Smaller size and greater reliability (compared to electro-mechanical relays)
- Reduced op-amp output error (SSR has low-offset voltage, low output capacitance, and good output linearity)
- Low power dissipation (only 1 mA turn-on current)

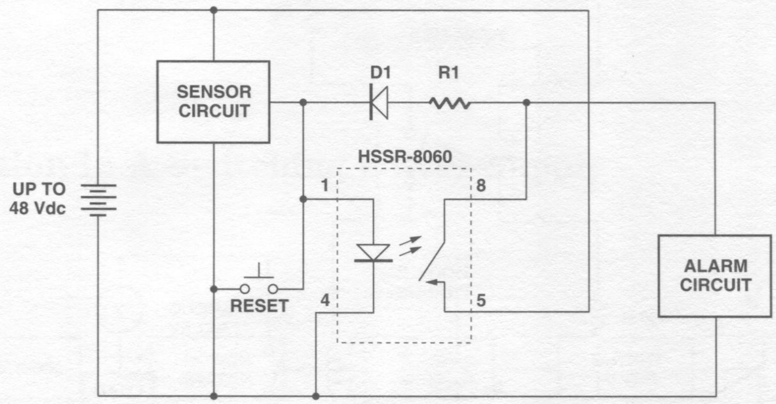
References

1) HSSR-8200 Solid State Relay Technical Data
2) HP Application Note 1036, "Small Signal Solid State Relay"

Alternative HP Parts

1) HSSR-8400, 400 V Solid State Relay
2) HSSR-8060, 60 V Solid State Relay
3) HSSR-7110/1, Hermetic Solid State Relay

Low Power Alarm Control Circuit



Description

In battery-powered alarm systems, the alarm circuit needs to be disconnected from the battery when not in use. The HSSR-8060 Solid State Relay reconnects the alarm circuit to the battery only when the sensor circuit is energized.

Performance of Solid State Relay

- Typical output on-resistance = 0.4 Ω for ac-connection; 0.1 Ω for dc-connection (refer to HSSR-8060 Solid-State Relay Technical Data for an explanation of ac and dc connections.)
- Maximum output steady-state current: 1.5 A for dc-connection; 0.75 A for ac-connection
- Maximum output withstand voltage: 60 V peak (either polarity for ac-connection)

Benefits of Solid State Relay

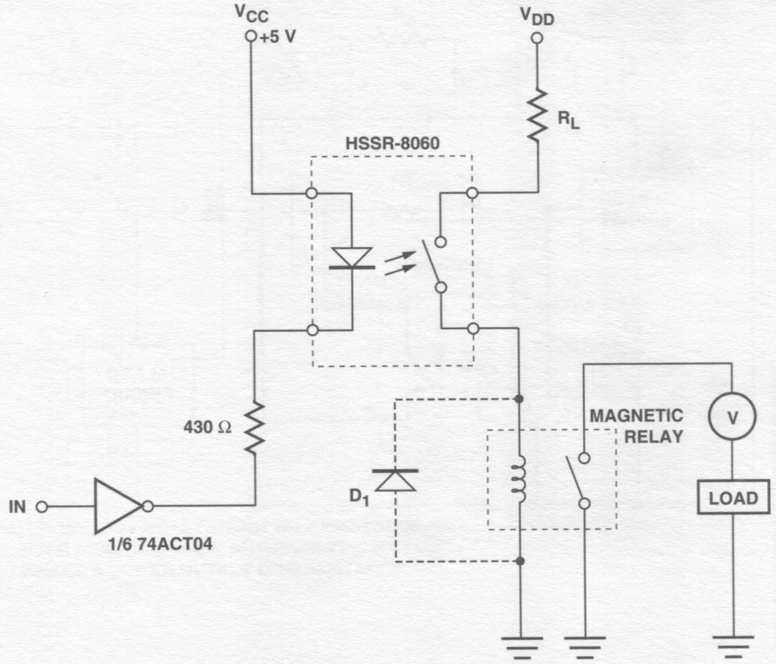
- Greater reliability compared to electro-mechanical relays
- Compact size
- Less power dissipation (low input turn-on current, and low output on-resistance)

References

1) HP Application Note 1046, "Low On-resistance Solid State Relays"
2) HSSR-8060 Solid State Relay Technical Data

Alternative HP Parts

1) HSSR-8400, 400 V Solid State Relay
2) HSSR-8200, 200 V Solid State Relay



Description

The HSSR-8060 Solid State Relay (SSR) can be used for driving the coil of a large electro-mechanical relay. This SSR can be controlled with TTL or CMOS 5 V logic, and requires only 5 mA for turn-on. Diode D_1 across the coil of the electro-magnetic relay protects the SSR output by limiting the back EMF of the coil during turn-off. The HSSR-8060 can switch up to 7.0 Amp transient current when the output is in the dc-connection.

Performance of Solid State Relay

- Maximum output withstand voltage: 60 V peak (either polarity for ac-connection)
- Typical on-resistance = 0.1 Ω for dc-connection
- Maximum steady-state current: 1.5 A for dc-connection; 0.75 A for ac-connection (refer to HSSR-8060 Solid-State Relay Technical Data for an explanation of ac and dc connections.)

Benefits of Solid State Relay

- Greater reliability compared to electro-mechanical relays
- Compact size
- Less power dissipation (low input turn-on current, and low output on-resistance)

References

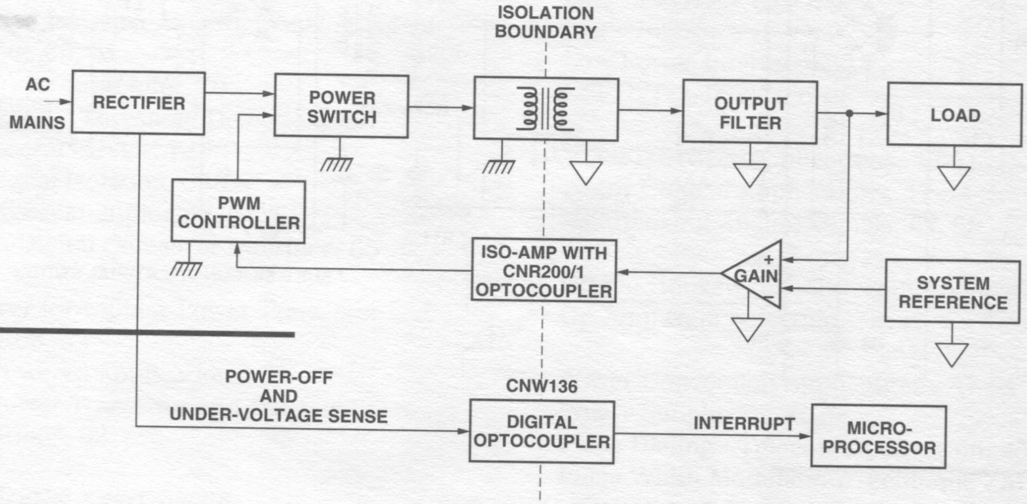
1) HP Application Note 1047 and 1046, “Low on-resistance Solid State Relays”
2) HSSR-8060 Solid State Relay Technical Data

Alternative HP Parts

1) HSSR-7110/1 Hermetic Solid State Relay
2) HSSR-8400, 400 V Solid State Relay

Power Supply Applications

Optical Isolation In A Switching Power Supply - Circuit No. 1



Description

Switching power supplies often need to couple digital and analog signals between the primary and secondary circuits. The above schematic shows an analog error signal representing the difference between the output voltage and the reference voltage being fed back to the primary side using a HCNR200/1 Analog Optocoupler. The analog error signal helps the pulse-width modulation (PWM) controller determine the exact pulse-width to make the filtered output voltage match the system reference voltage. In a similar manner, the HCNW136 Digital Optocoupler can be used to monitor the primary side power-off and under-voltage condition.

Performance of Optocoupler

- HCNR200/1 has 0.01% non-linearity and up to 1 MHz bandwidth
- HCNW135 has 0.2 µs typical propagation delay time
- Both HCNR200/1 and HCNW136 optocouplers meet worldwide regulatory insulation guidelines

Benefits

- Accurate monitoring and control of secondary output voltage
- Power off condition detectable at an early stage enabling the microprocessor to save critical information

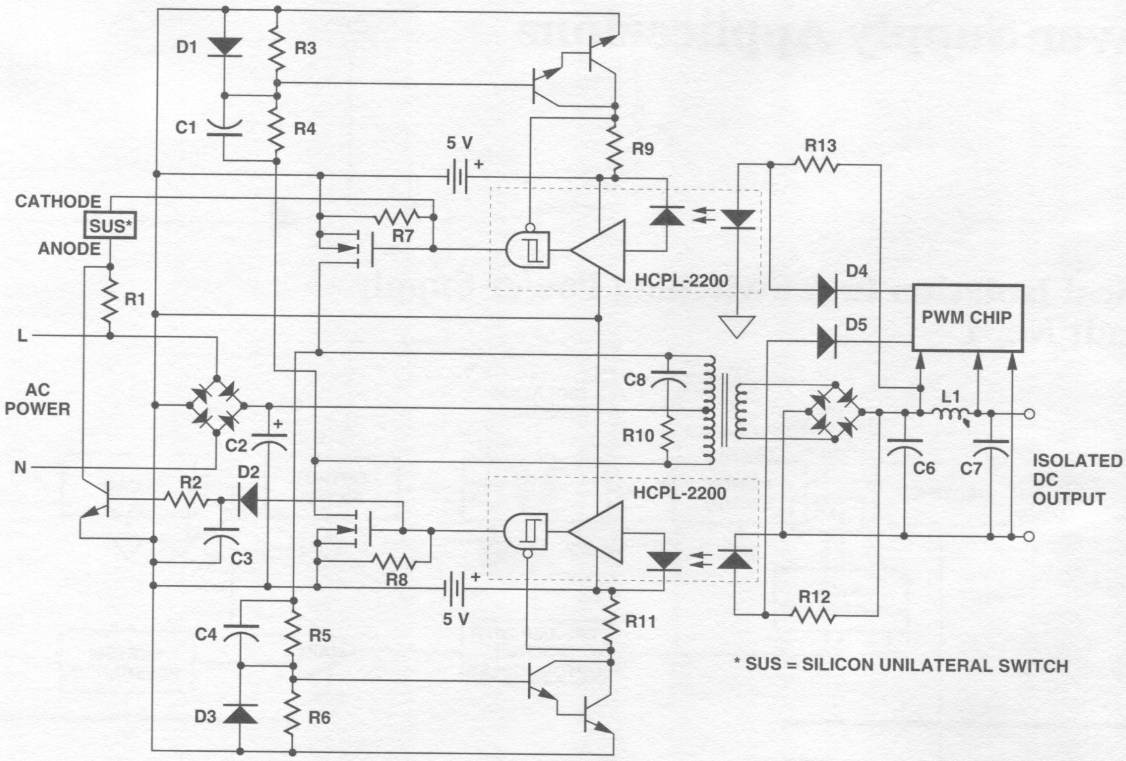
References

1) HCNR200/1 Analog Optocoupler Technical Data
2) HCNW136 High Speed Optocoupler Technical Data

Alternative HP Parts

1) HCPL-7800/7820 Isolation Amplifier
2) HCPL-4503, HCNW4503 High CMR Digital Optocoupler
3) HCNW2601/11 Widebody, High Speed Digital Optocoupler

Optical Isolation In A Switching Power Supply - Circuit No. 2



Description

The above figure shows a push-pull switching power supply that utilizes the HCPL-2200 optocoupler to drive switching transistors. The above circuit uses a silicon unilateral switch (SUS) to bootstrap start the power supply when power is first applied. The inhibit function in the HCPL-2200 optocoupler has been used to good advantage to provide a common-mode conduction interlock function that will not allow both the switching transistors to turn on at the same time.

Performance of Optocoupler

- Maximum propagation delay: 300 ns
- Input turn-on current: 1.6 mA
- Common-mode transient rejection: 1000 V/μs

Benefits

- The power switches are protected from common-mode conduction failures caused by EMI
- Regulation range is increased since no deadtime is required
- Design is tolerant to propagation delay changes due to lot-to-lot component variations

References

HCPL-2200 High CMR Optocoupler Technical Data

Alternative HP Parts

1) HCPL-2219 Very High CMR Optocoupler
2) HCNW2601/11 Widebody High CMR Optocoupler

Optocoupler Applications Index

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