8 MBd Low Input Current Optocoupler

Technical Data

HCPL-2300

Features

- **Guaranteed Low Thresholds: I_F = 0.5 mA, $V_F \leq 1.5$ V**
- **High Speed: Guaranteed 5 MBd over Temperature**
- **Versatile: Compatible with TTL, LSTTL and CMOS**
- **Efficient 820 nm AlGaAs LED**
- **Internal Shield for Guaranteed Common Mode Rejection**
- **Schottky Clamped, Open Collector Output with Optional Integrated Pull-Up Resistor**
- **Static and Dynamic Performance Guaranteed from -40°C to 85°C**
- **Safety Approval**
  UL Recognized -2500 V rms for 1 minute
  CSA Approved
  VDE 0884 Approved with V_{IORM} = 630 V peak (Option 060)

Applications

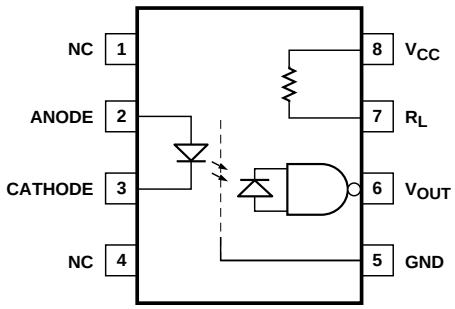
- **Ground Loop Elimination**
- **Computer-Peripheral Interfaces**
- **Level Shifting**
- **Microprocessor System Interfaces**
- **Digital Isolation for A/D, D/A Conversion**
- **RS-232-C Interface**
- **High Speed, Long Distance Isolated Line Receiver**

Description

The HCPL-2300 optocoupler combines an 820 nm AlGaAs photon emitting diode with an integrated high gain photon detector. This combination of Hewlett-Packard designed and manufactured semiconductor devices brings new high performance capabilities to designers of isolated logic and data communication circuits.

The new low current, high speed AlGaAs emitter manufactured with a unique diffused junction, has the virtue of fast rise and fall times at low drive currents. Figure 6 illustrates the propagation delay vs. input current characteristic. These unique

Functional Diagram



A 0.1 pF bypass capacitor must be connected between pins 5 and 8.

CAUTION: It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

5965-3587E

characteristics enable this device to be used in an RS-232-C interface with ground loop isolation and improved common mode rejection. As a line receiver, the HCPL-2300 will operate over longer line lengths for a given data rate because of lower I_F and V_F specifications.

The output of the shielded integrated detector circuit is an open collector Schottky clamped transistor. The shield, which shunts capacitively coupled common mode noise to ground, provides a guaranteed transient immunity specification of 100 V/µs. The output circuit includes an optional integrated 1000 Ω pull-up resistor for the open collector. This gives designers the flexibility to use the internal resistor for pull-up to five volt logic or to use an external resistor for connection to supply voltages up to 18 V (CMOS logic voltage).

The Electrical and Switching Characteristics of the HCPL-2300 are guaranteed over a temperature range of -40°C to 85°C. This enables the user to confidently design a circuit which will operate under a broad range of operating conditions.

Ordering Information

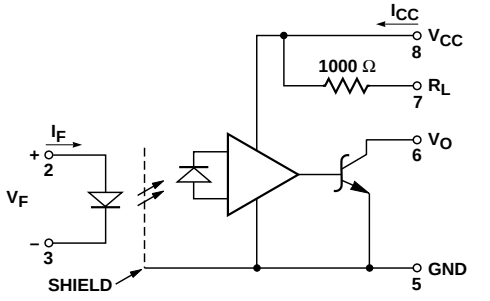
Specify part number followed by Option Number (if desired).

HCPL-2300# XXX

- 060 = VDE 0884 V_{IORM} = 630 V $_{peak}$ Option
- 300 = Gull Wing Surface Mount Lead Option
- 500 = Tape/Reel Package Option (1 K min)

Option data sheets available. Contact your Hewlett-Packard sales representative or authorized distributor for information.

Schematic



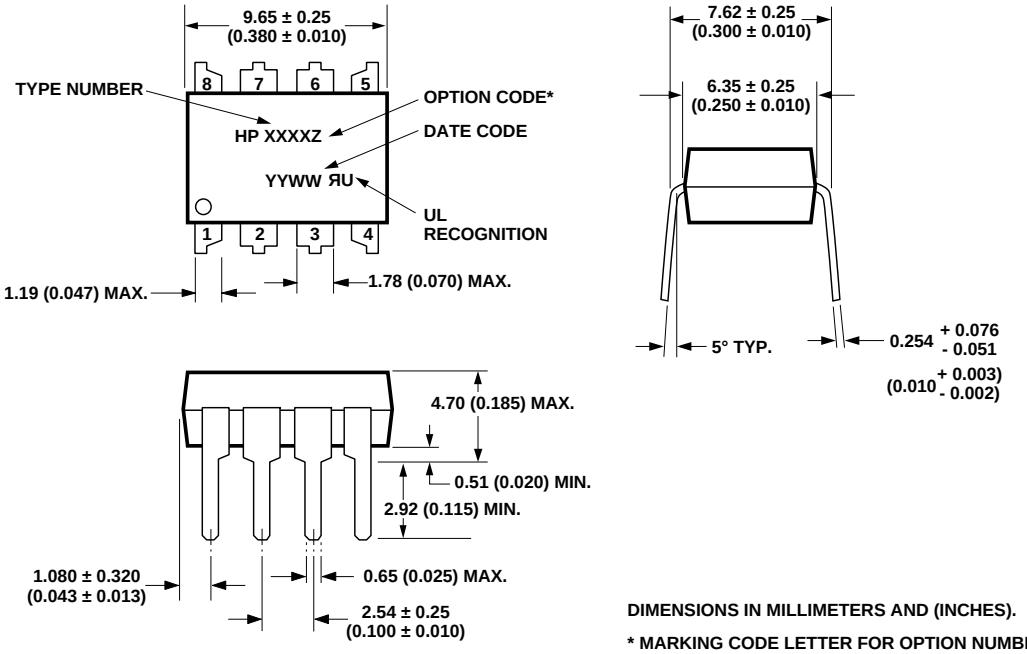
A 0.1 µF CAPACITOR MUST BE CONNECTED BETWEEN PINS 8 AND 5 (SEE NOTE 1).

TRUTH TABLE (POSITIVE LOGIC)

LED	OUTPUT
ON	L
OFF	H

Package Outline Drawings

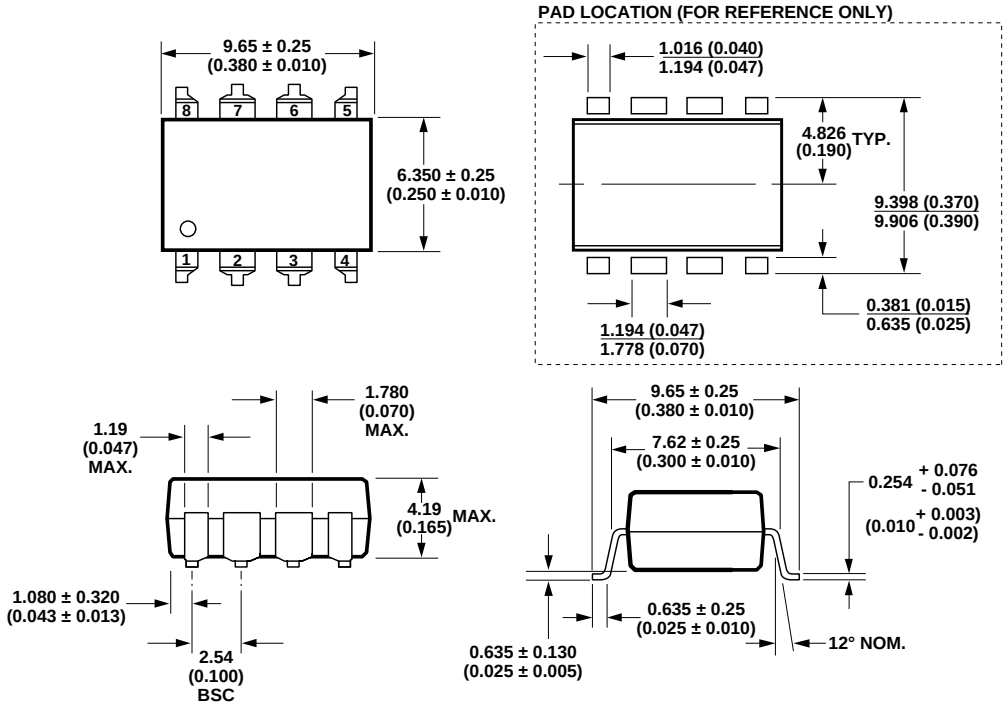
8-Pin DIP Package (HCPL-2300)



DIMENSIONS IN MILLIMETERS AND (INCHES).

* MARKING CODE LETTER FOR OPTION NUMBERS.
"V" = OPTION 060
OPTION NUMBERS 300 AND 500 NOT MARKED.

8-Pin DIP Package with Gull Wing Surface Mount Option 300 (HCPL-2300)



DIMENSIONS IN MILLIMETERS (INCHES).
LEAD COPLANARITY = 0.10 mm (0.004 INCHES).

Thermal Profile (Option #300)

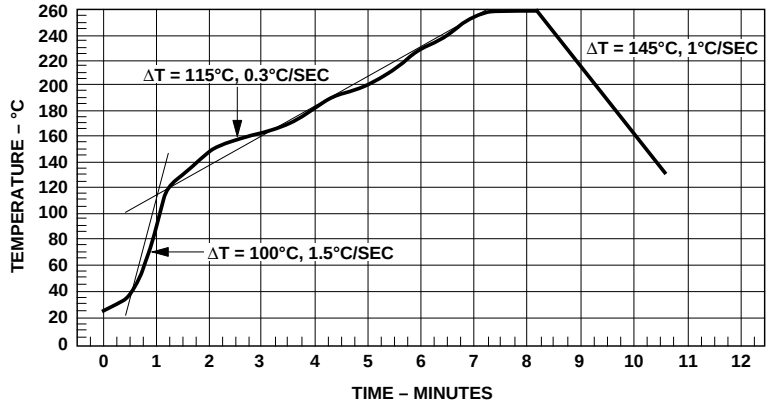


Figure 1. Maximum Solder Reflow Thermal Profile.
(Note: Use of non-chlorine activated fluxes is recommended.)

Regulatory Information

The HCPL-2300 has been approved by the following organizations:

UL

Recognized under UL 1577, Component Recognition Program, File E55361.

CSA

Approved under CSA Component Acceptance Notice #5, File CA 88324.

VDE

Approved according to VDE 0884/06.92 (Option 060 only)

Insulation and Safety Related Specifications

Parameter	Symbol	Value	Units	Conditions
Min. External Air Gap (External Clearance)	L(IO1)	7.1	mm	Measured from input terminals to output terminals, shortest distance through air
Min. External Tracking Path (External Creepage)	L(IO2)	7.4	mm	Measured from input terminals to output terminals, shortest distance path along body
Min. Internal Plastic Gap (Internal Clearance)		0.08	mm	Through insulation distance, conductor to conductor, usually the direct distance between the photoemitter and photodetector inside the optocoupler cavity
Tracking Resistance (Comparative Tracking Index)	CTI	200	Volts	DIN IEC 112/VDE 0303 PART 1
Isolation Group		IIIa		Material Group (DIN VDE 0110, 1/89, Table 1)

Option 300 – surface mount classification is Class A in accordance with CECC 00802.

VDE 0884 Insulation Related Characteristics (HCPL-2300 Option 060 ONLY)

Description	Symbol	Characteristic	Units
Installation classification per DIN VDE 0110/1.89, Table 1			
for rated mains voltage ≤ 300 V rms		I-IV	
for rated mains voltage ≤ 450 V rms		I-III	
Climatic Classification		55/85/21	
Pollution Degree (DIN VDE 0110/1.89)		2	
Maximum Working Insulation Voltage	V_{IORM}	630	V peak
Input to Output Test Voltage, Method b* V_{IORM} x 1.875 = V_{PR}, 100% Production Test with t_m = 1 sec, Partial Discharge < 5 pC	V_{PR}	1181	V peak
Input to Output Test Voltage, Method a* V_{IORM} x 1.5 = V_{PR}, Type and sample test, t_m = 60 sec, Partial Discharge < 5 pC	V_{PR}	945	V peak
Highest Allowable Overvoltage* (Transient Overvoltage, t_{ini} = 10 sec)	V_{IOTM}	6000	V peak
Safety Limiting Values (Maximum values allowed in the event of a failure, also see Figure 11, Thermal Derating curve.)			
Case Temperature	T_S	175	°C
Input Current	$I_{S,INPUT}$	230	mA
Output Power	$P_{S,OUTPUT}$	600	mW
Insulation Resistance at T_S, V_{IO} = 500 V	R_S	$\geq 10^9$	Ω

*Refer to the front of the optocoupler section of the current catalog, under Product Safety Regulations section, (VDE 0884), for a detailed description.

Note: Isolation characteristics are guaranteed only within the safety maximum ratings which must be ensured by protective circuits in application.

Absolute Maximum Ratings

(No Derating Required up to 55°C)

Storage Temperature, T_S ..... -55°C to +125°C
Operating Temperature, T_A ..... -40°C to +85°C
Lead Solder Temperature, max ..... 260°C for 10 s
(1.6 mm below seating plane)
Average Forward Input Current - I_F ..... 5 mA[2]
Reverse Input Voltage, V_R ..... 3.0 V
Supply Voltage, V_{CC} ..... 0 V to 7.0 V
Pull-Up Resistor Voltage, V_{RL} ..... -0.5 V to V_{CC}
Output Collector Current, I_O ..... -25 to 25 mA
Input Power Dissipation, P_I ..... 10 mW
Output Collector Power Dissipation, P_O ..... 40 mW
Output Collector Voltage, V_O ..... -0.5 V to 18 V
Infrared and Vapor Phase Reflow Temperature
(Option #300) ..... see Fig. 1, Thermal Profile

Recommended Operating Conditions

Parameter		Symbol	Min.	Max.	Units
Input Voltage, Low Level		V_{FL}	-2.5	0.8	V
Input Current High Level	0°C to 85°C	I_{FH}	0.5	1.0	mA
	-40°C to 85°C		0.5	0.75	
Supply Voltage, Output		V_{CC}	4.75	5.25	V
Fan Out (TTL Load)		N		5	
Operating Temperature		T_A	-40	85	°C

DC Electrical Specifications

For -40°C ≤ T_A ≤ 85°C, 4.75 V ≤ V_{CC} ≤ 5.25 V, V_{FL} ≤ 0.8 V, unless otherwise specified.
All typicals at T_A = 25°C and V_{CC} = 5 V , unless otherwise specified. See note 1.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	I_{OH}		0.05	250	µA	V_F = 0.8 V, V_O = 18 V	4	
Low Level Output Voltage	V_{OL}		0.4	0.5	V	I_F = 0.5 mA I_{OL} (Sinking) = 8 mA	3	
High Level Supply Current	I_{CCH}		4.0	6.3	mA	I_F = 0 mA, V_{CC} = 5.25 V		
Low Level Supply Current	I_{CCL}		6.2	10.0	mA	I_F = 1.0 mA, V_{CC} = 5.25 V		
Input Forward Voltage	V_F	1.0	1.3	1.5	V	T_A = 25°C | I_F = 1.0 mA	2	
		0.85		1.65				
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.6		mV/°C	I_F = 1.0 mA		
Input Reverse Breakdown Voltage	BV_R	3.0			V	I_R = 10 µA		
Input Capacitance	C_{IN}		18		pF	V_F = 0 V, f = 1 MHz		
Internal Pull-up Resistor	R_L	680	1000	1700	Ω	T_A = 25°C		

Switching Specifications

For -40°C ≤ T_A ≤ 85°C, 0.5 mA ≤ I_{FH} ≤ 0.75 mA;
For 0°C ≤ T_A ≤ 85°C, 0.5 mA ≤ I_{FH} ≤ 1.0 mA; With 4.75 V ≤ V_{CC} ≤ 5.25 V, V_{FL} ≤ 0.8 V, unless otherwise specified. All typicals at T_A = 25°C and V_{CC} = 5 V, I_{FH} = 0.625 mA, unless otherwise specified. See note 1.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to Logic High Output Level	t_{PLH}		95		ns	C_P = 0 pF	5, 6, 8	4, 8
			85	160		C_P = 20 pF	5, 8	
Propagation Delay Time to Logic Low Output Level	t_{PHL}		110		ns	C_P = 0 pF	5, 6, 8	5, 8
			35	200		C_P = 20 pF	5, 8	
Output Rise Time (10-90%)	t_r		40		ns	C_P = 20 pF	7, 8	8
Output Fall Time (90-10%)	t_f		20		ns			
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	100	400		V/µs	V_{CM} = 50 V (peak), V_O (min.) = 2 V, R_L = 560 Ω, I_F = 0 mA	9, 10	6
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	100	400		V/µs	V_{CM} = 50 V (peak), V_O (max.) = 0.8 V, R_L = 560 Ω, I_F = 0.5 mA	9, 10	7

Package Characteristics

For -40°C ≤ T_A ≤ 85°C, unless otherwise specified. All typicals at T_A = 25°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Notes
Input-Output Momentary Withstand Voltage*	V_{ISO}	2500			V rms	RH ≤ 50%, t = 1 min, T_A = 25°C		3, 9
Resistance, Input-Output	R_{I-O}		10^{12}		Ω	V_{I-O} = 500 V		3
Capacitance, Input-Output	C_{I-O}		0.6		pF	f = 1 MHz		3

*The Input-Output Momentary Withstand Voltage is a dielectric voltage rating that should not be interpreted as an input-output continuous voltage rating. For the continuous voltage rating refer to the VDE 0884 Insulation Characteristics Table (if applicable), your equipment level safety specification, or HP Application Note 1074, "Optocoupler Input-Output Endurance Voltage."

Notes:

1. Bypassing the power supply line is required with a 0.1 µF ceramic disc capacitor adjacent to each optocoupler as illustrated in Figure 19. The power supply bus for the optocoupler(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.5 µF) may be needed to suppress regenerative feedback via the power supply.
2. Peaking circuits may produce transient input currents up to 100 mA, 500 ns maximum pulse width, provided average current does not exceed 5 mA.
3. Device considered a two terminal device: pins 1, 2, 3, and 4 shorted together, and pins 5, 6, 7, and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
5. The t_{PHL} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.5 V point on the leading edge of the output pulse.
6. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e., V_{OUT} > 2.0 V).
7. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., V_{OUT} < 0.8 V).
8. C_P is the peaking capacitance. Refer to test circuit in Figure 8.
9. In accordance with UL 1577, each optocoupler is momentary withstand proof tested by applying an insulation test voltage ≥ 3000 Vrms for 1 second (leakage detection current limit, I_{I-O} ≤ 5 µA). This test is performed before the 100% production test for partial discharge (Method b) shown in the VDE 0884 Insulation Characteristics Table, if applicable.

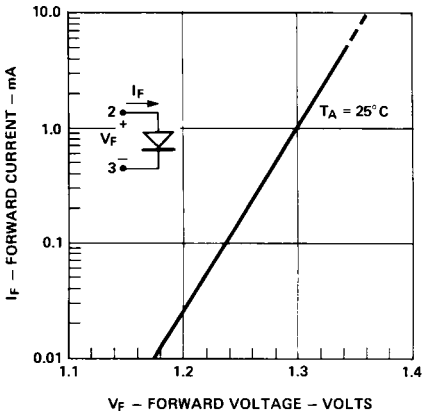


Figure 2. Typical Input Diode Forward Characteristics.

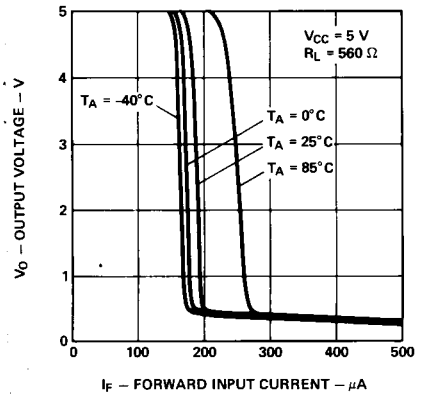


Figure 3. Typical Output Voltage vs. Forward Input Current vs. Temperature.

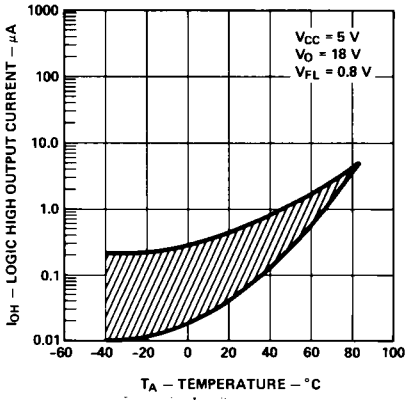


Figure 4. Typical Logic High Output Current vs. Temperature.

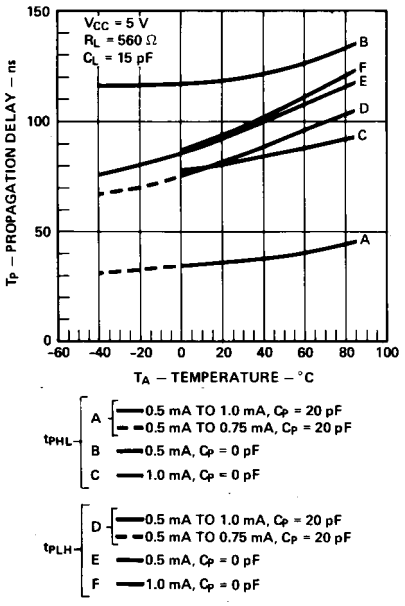


Figure 5. Typical Propagation Delay vs. Temperature and Forward Current with and without Application of a Peaking Capacitor.

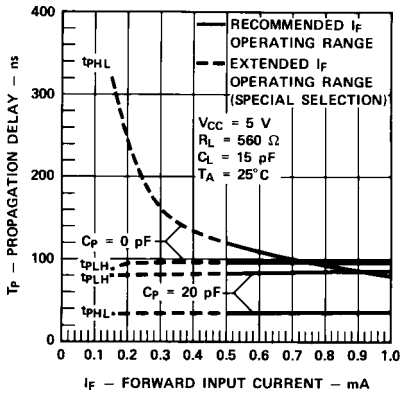


Figure 6. Typical Propagation Delay vs. Forward Current.

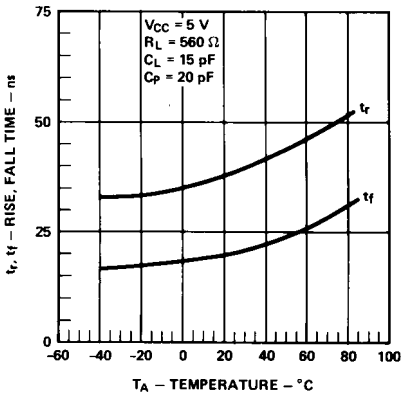


Figure 7. Typical Rise, Fall Time vs. Temperature.

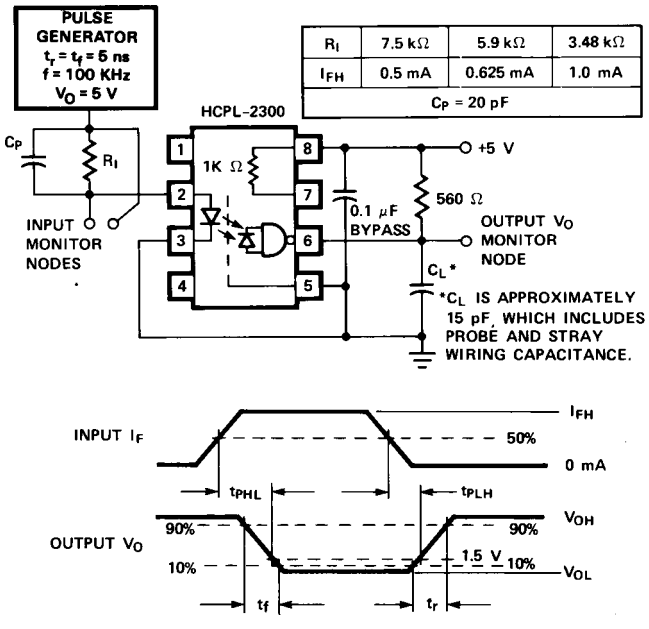


Figure 8. Test Circuit for t_{PHL}, t_{PLH}, t_r, and t_f.

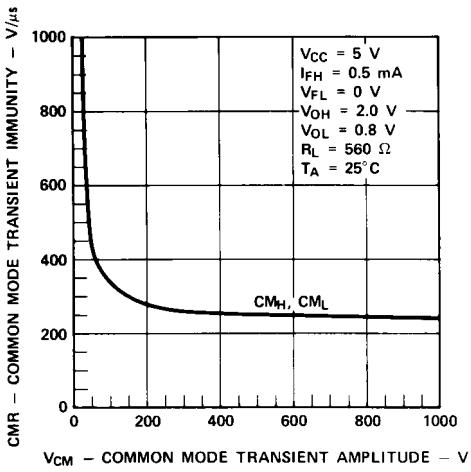


Figure 9. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude.

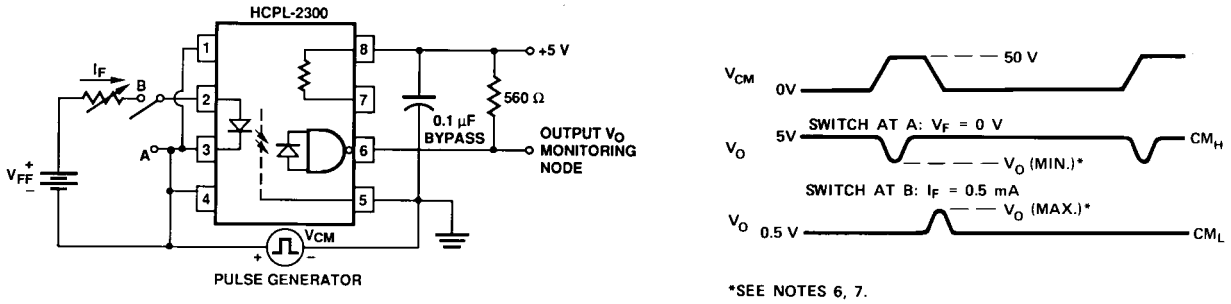


Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

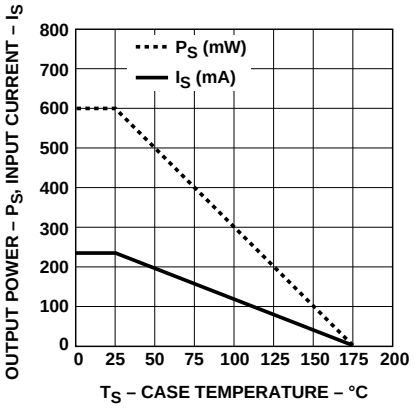


Figure 11. Thermal Derating Curve, Dependence of Safety Limiting Value with Case Temperature per VDE 0884.

Applications

The HCPL-2300 optocoupler has the unique combination of low 0.5 mA LED operating drive current at a 5 MBd speed performance. Low power supply current requirement of 10 mA maximum at 5.25 V and the ability to provide isolation between logic systems fulfills numerous applications ranging from logic level translations, line receiver and party line receiver applications, microprocessor I/O port isolation, etc. The open collector output allows for wired-OR arrangement. Specific interface circuits are illustrated in Figures 12-16, and 18 with corresponding component values, performance data and recommended layout in Figures 17 and 19.

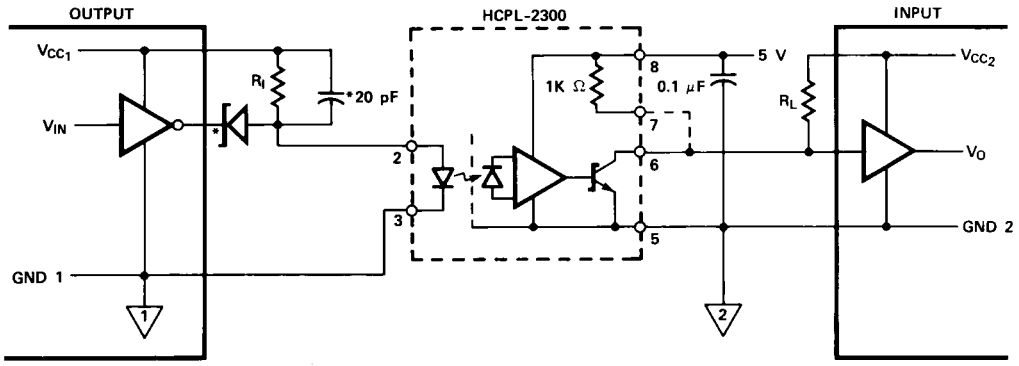
For -40°C to 85°C operating temperature range, a mid-range LED forward current (I_F) of 0.625 mA is recommended in order to prevent overdriving the integrated circuit detector due to increased LED efficiency at temperatures between 0°C and -40°C. For narrower temperature range of 0°C to 85°C, a suggested operating LED current of 0.75 mA is recommended for the mid-range operating point and for minimal propagation delay skew. A peaking capacitance of 20 pF in parallel with the current limiting resistor for the LED shortens t_{PHL} by approximately 33% and t_{PLH} by 13%. Maintaining LED forward voltage (V_F) below 0.8 V will guarantee that the HCPL-2300 output is off.

The recommended shunt drive technique for TTL/LSTTL/CMOS of Figure 12 provides for optimal speed performance, no leakage current path through the LED, and reduced common mode influences associated with series switching of a “floating” LED. Alternate series drive techniques with either an active CMOS inverter or an open collector TTL/LSTTL inverter are illustrated in Figures 13 and 14 respectively. Open collector leakage current of 250 μA has been compensated by the 3.16 KΩ resistor (Figure 14) at the expense of twice the operating forward current.

An application of the HCPL-2300 as an unbalanced line receiver for use in long line twisted wire pair communication links is shown in Figure 15. Low LED I_F and V_F allow longer line length, higher speed and multiple stations on the line in comparison to higher I_F, V_F optocouplers. Greater speed performance along with nearly infinite common mode immunity are achieved via the balanced split phase circuit of Figure 16. Basic balanced differential line receiver can be accomplished with one HCPL-2300 in Figure 16, but with a typical 400 V/μs common mode immunity. Data rate versus distance for both the above unbalanced and balanced line receiver applications are compared in Figure 17. The RS-232-C interface circuit of Figure 18

provides guaranteed minimum common mode immunity of 100 V/μs while maintaining the 2:1 dynamic range of I_F.

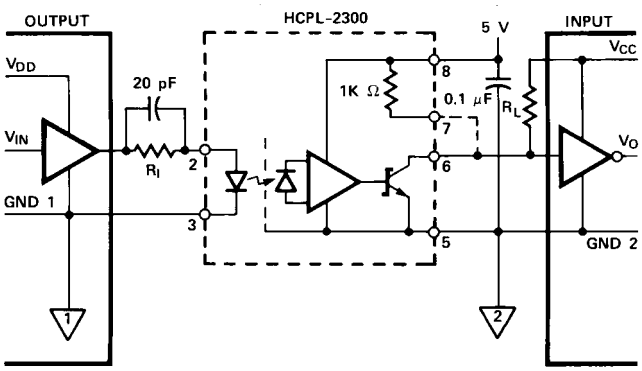
A recommended layout for use with an internal 1000 Ω resistor or an external pull-up resistor and required V_{CC} bypass capacitor is given in Figure 19. V_{CC1} is used with an external pull-up resistor for output voltage levels (V_O) greater than or equal to 5 V. As illustrated in Figure 19, an optional V_{CC} and GND trace can be located between the input and the output leads of the HCPL-2300 to provide additional noise immunity at the compromise of insulation capability (V_{I-O}).



V_{IN} V_{DC}	V_{CC1} V_{DC}	R_I kΩ	R_L kΩ	V_{CC2} V_{DC}
5	5	6.19	1 (INTERNAL)	5
10	10	14.7	2.37	10
15	15	21.5	3.16	15

*SCHOTTKY DIODE (HP 5082-2800, OR EQUIVALENT) AND 20 pF CAPACITOR ARE NOT REQUIRED FOR UNITS WITH OPEN COLLECTOR OUTPUT.

Figure 12. Recommended Shunt Drive Circuit for Interfacing between TTL/LSTTL/CMOS Logic Systems.



V_{IN} V_{DC}	V_{DD} V_{DC}	R_I kΩ	R_L kΩ	V_{CC} V_{DC}
5	5	5.11	1 (INTERNAL)	5
10	10	13.3	2.37	10
15	15	19.6	3.16	15

Figure 13. Active CMOS Series Drive Circuit.

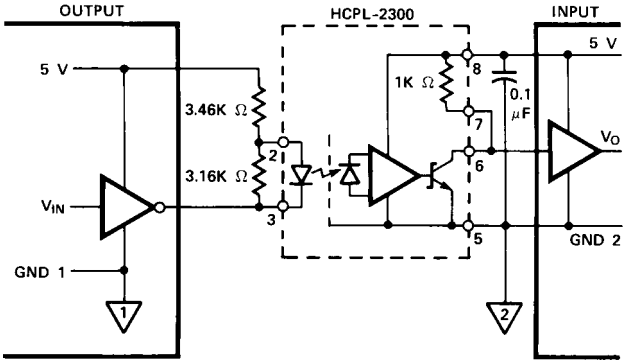


Figure 14. Series Drive from Open Collector TTL/LSTTL Units.

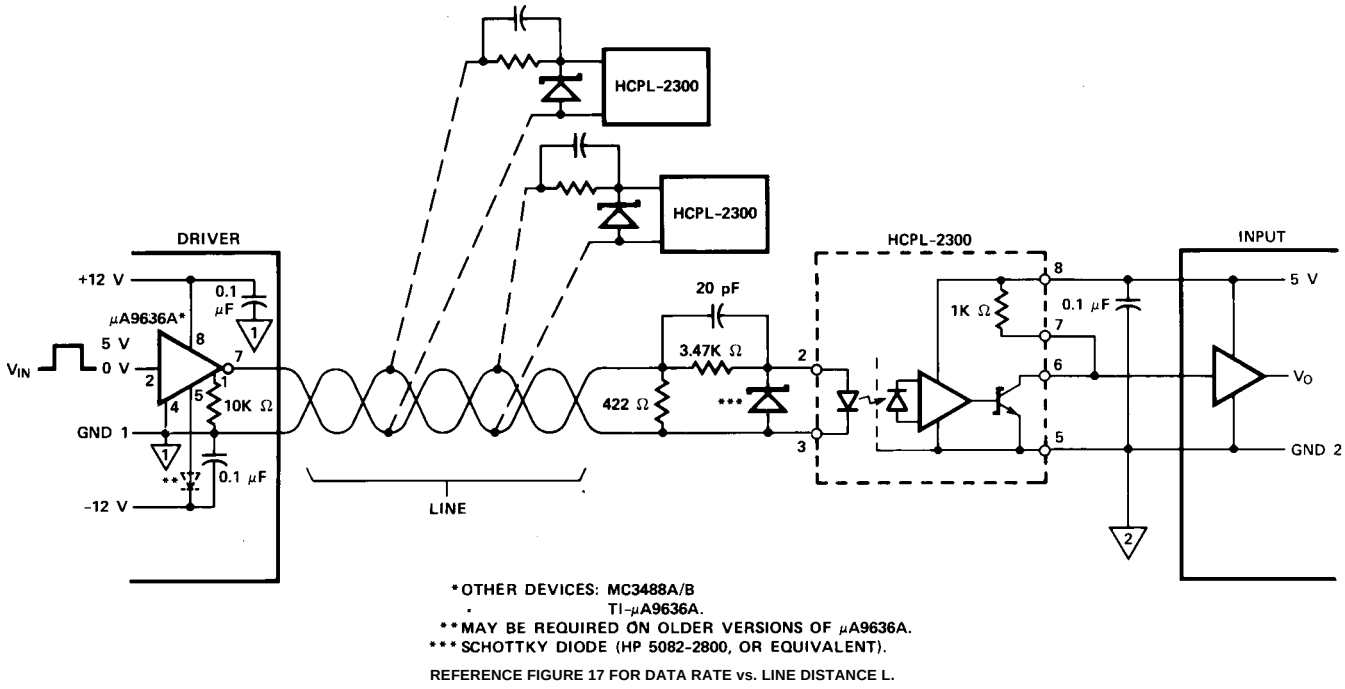


Figure 15. Application of HCPL-2300 as Isolated, Unbalanced Line Receiver(s).

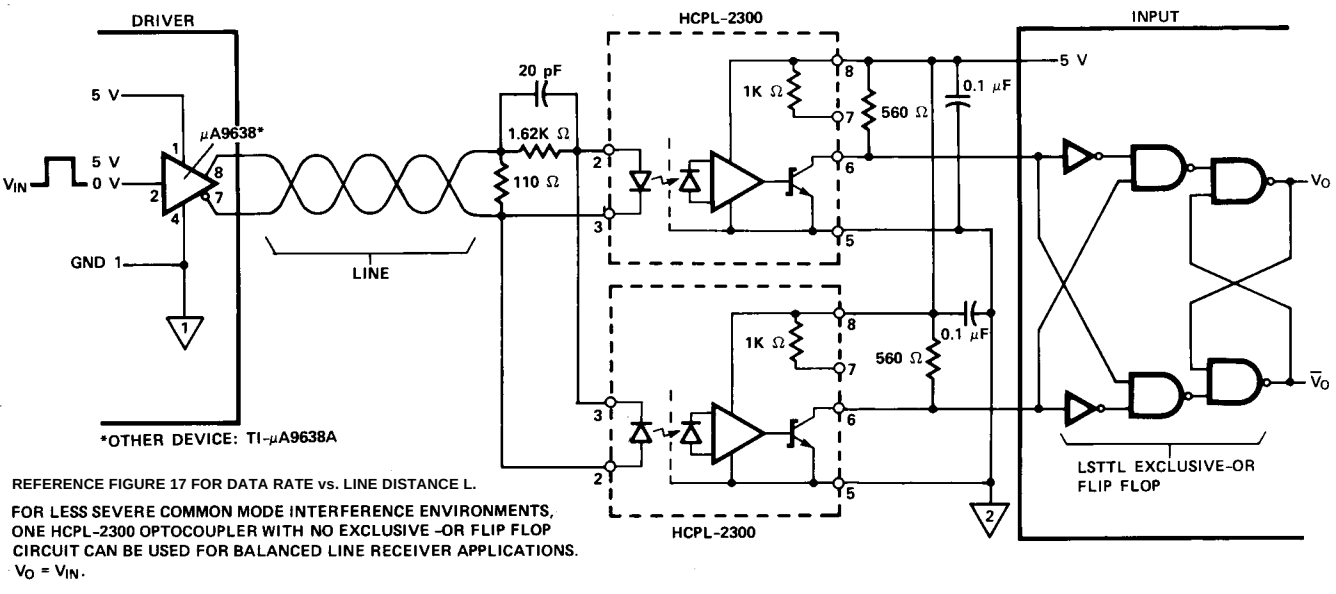


Figure 16. Application of Two HCPL-2300 Units Operating as an Isolated, High Speed, Balanced, Split Phase Line Receiver with Significantly Enhanced Common Mode Immunity.

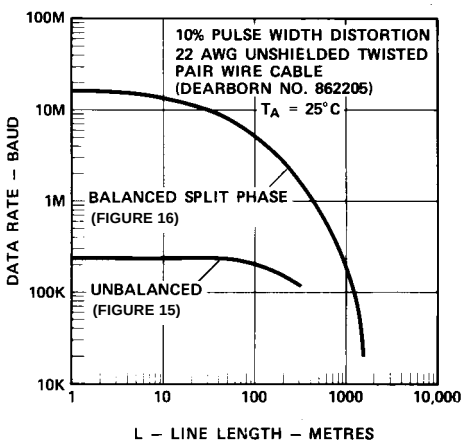


Figure 17. Typical Point to Point Data Rate vs. Length of Line for Unbalanced (Figure 15) and Balanced (Figure 16) Line Receivers Using HCPL-2300 Optocouplers.

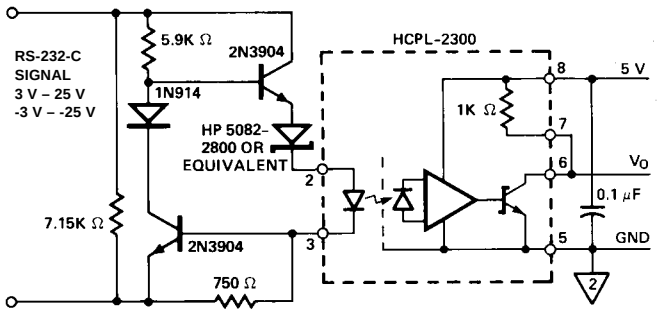


Figure 18. RS-232-C Interface Circuit with HCPL-2300. $0°C < T_A < 85°C$.

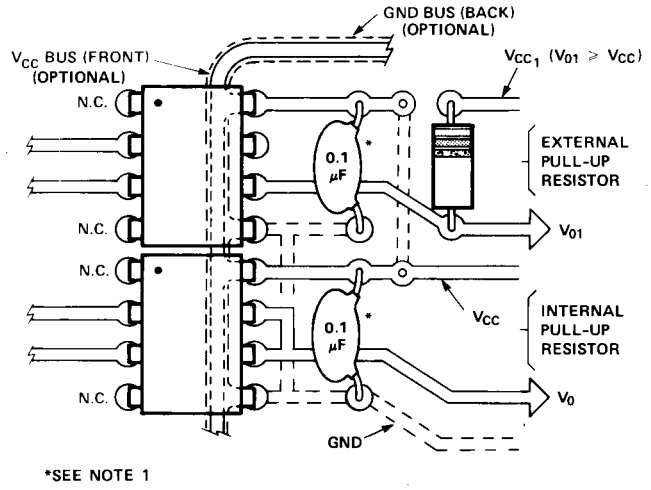


Figure 19. Recommended Printed Circuit Board Layout.