

# GENERAL INSTRUMENT

# HIGH-SPEED TRANSISTOR OPTOCOUPLEDERS

Optocouplers

## MCL2501 MCL2503 (HCPL-2503) MCL2502 (HCPL-2502) 6N136 6N135

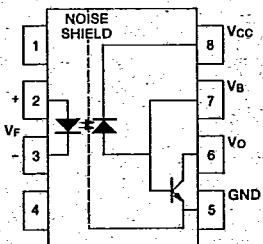
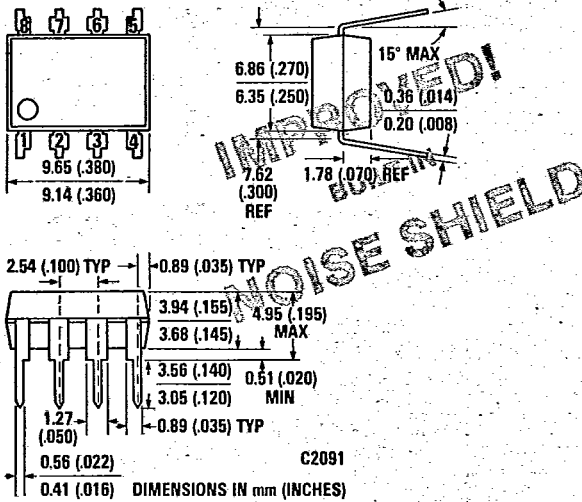
### MINIMUM CTR SELECTION CHART

	CTR @ $I_F = 8 \text{ mA}$		CTR @ $I_F = 16 \text{ mA}$	
	0-70°C	25°C	0-70°C	25°C
MCL 2501	14%	17%	17%	21%
MCL/HCPL-2503	11%	15%	9%	12%
6N136	—	—	15%	19%
6N135	—	—	5%	7%
MCL/HCPL-2502	—	—	—	15%-22% MAX

### PROPAGATION DELAY COMPARISON

	$I_F = 8 \text{ mA}$		$I_F = 16 \text{ mA}$	
	0-70°C	25°C	0-70°C	25°C
MCL2501	MCL/ HCPL-2503	MCL2501	MCL/ HCPL-2502	6N136 6N135

### PACKAGE DIMENSIONS



Equivalent Circuit C1982

### DESCRIPTION

The MCL2501, MCL/HCPL-2503/02 and 6N136/5 optocouplers contain a 700 nm GaAsP LED emitter, which is optically coupled to a high speed photodetector transistor.

A separate connection for the bias of the photodiode improves the speed by several orders of magnitude over conventional phototransistor optocouplers by reducing the base-collector capacitance of the input transistor.

An internal noise shield provides superior common mode rejection of 10 kV/ $\mu$ s. An improved package allows superior insulation permitting a 480 V working voltage compared to industry standard of 220 V.

The prime device in this family is MCL2501 which guarantees all DC parameters including CTR as well as all switching parameters over 0-70°C at both 8 mA and 16 mA input current.

### FEATURES

- MCL2501 completely guaranteed 0-70°C at 8 and 16 mA.
- High Speed — 1 MBit/s
- Superior CMR — 10 kV/ $\mu$ s
- Superior insulation — 2500 V RMS 1 min
- Double working voltage — 480 V RMS
- CTR guaranteed 0-70°C
- U.L. recognized (File #E50151)

### APPLICATIONS

- Line receivers
- Pulse transformer replacement
- Output interfact to CMOS-LSTTL-TTL
- Wide bandwidth analog coupling

**MCL2501 MCL2503/2 (HCPL-2503/2) 6N136/5**

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ELECTRICAL CHARACTERISTICS ( $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$  Unless Otherwise Specified)

T-41-83

PARAMETER	SYMBOL	TEST CONDITIONS	MCL2501			MCL/HCPL-2503			MCL/HCPL-2502			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Current transfer ratio	CTR	$I_F=16\text{mA}, V_O=0.4\text{V}, V_{CC}=4.5\text{V}, T_A=25^\circ\text{C}$	21	28		12	18		15		22	%
		$I_F=16\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}$	17			9						
		$I_F=8\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}, T_A=25^\circ\text{C}$	17	36		15						
		$I_F=8\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}$ Note 5, Fig. 1, 2	14			11						
Logic low output voltage	$V_{OL}$	$I_F=16\text{mA}, I_O=1.1\text{mA}, V_{CC}=4.5\text{V}$					0.2	0.5				V
		$I_F=16\text{mA}, I_O=2.4\text{mA}, V_{CC}=4.5\text{V}$		0.1	0.4					0.1	0.4	
		$I_F=8\text{mA}, I_O=0.7\text{mA}, V_{CC}=4.5\text{V}$		0.2	0.5		0.2	0.5				
Logic high output current	$I_{OH}$	$I_F=0\text{mA}, V_O=V_{CC}=5.5\text{V}, T_A=25^\circ\text{C}$								.003	.5	$\mu\text{A}$
		$I_F=0\text{mA}, V_O=V_{CC}=15\text{V}, T_A=25^\circ\text{C}$		0.01	1					0.01	1	
		$I_F=0\text{mA}, V_O=V_{CC}=15\text{V}$ Fig. 7			50						50	
Logic low supply current	$I_{CCL}$	$I_F=16\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}$								40		$\mu\text{A}$
		$I_F=8\text{mA}, V_O=\text{Open}, V_{CC}=5.5\text{V}$		20			20					
Logic high supply current	$I_{CCH}$	$I_F=0\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}, T_A=25^\circ\text{C}$		0.02	1					0.02	1	$\mu\text{A}$
		$I_F=0\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}$			2						2	
Input forward voltage	$V_F$	$I_F=16\text{mA}, T_A=25^\circ\text{C}$		1.5	1.7		1.5	1.7		1.5	1.7	V
		$I_F=8\text{mA}, T_A=25^\circ\text{C}$ Fig. 3		1.5	1.7		1.5	1.7				
Input reverse breakdown voltage	$BV_R$	$I_F=10\mu\text{A}, T_A=25^\circ\text{C}$	5			5			5			V
Temp. coefficient of forward voltage	$V_F$	$I_F=16\text{mA}$		-1.6			-1.6			-1.6		$\text{mV}/^\circ\text{C}$
Input-Output insulation leakage	$I_{I-O}$	45% Relative Humidity $t=5\text{sec}$ $V_{I-O}=3000\text{V}_{DC}, T_A=25^\circ\text{C}$ Note 6		—			—			—		$\mu\text{A}$
Withstand insulation test voltage	$V_{ISO}$	$RH \leq 50\% t = 1\text{min}$ $T_A=25^\circ\text{C}$ Notes 6, 11, 12	2500			2500			2500			V RMS
Resistance (Input-Output)	$R_{I-O}$	$V_{I-O}=500\text{V}_{DC}$ Note 6		$10^{12}$			$10^{12}$			$10^{12}$		$\Omega$
Capacitance (Input-Output)	$C_{I-O}$	$F=1\text{MHz}$ Note 6		0.6			0.6			0.6		pF
DC current gain	$h_{FE}$	$I_O=3\text{mA}, V_O=5\text{V}$		150			150			150		—

All typical values are at  $T_A=25^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS ( $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ Unless Otherwise Specified)

T-41-83

Optocouplers

PARAMETER	SYMBOL	TEST CONDITIONS	6N136			6N135			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Current transfer ratio	CTR	$I_F=16\text{mA}, V_O=0.4\text{V}, V_{CC}=4.5\text{V}, T_A=25^\circ\text{C}$	*19	24		*7	18		%
		$I_F=16\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}$	15			5			
		$I_F=8\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}, T_A=25^\circ\text{C}$							
		$I_F=8\text{mA}, V_O=0.5\text{V}, V_{CC}=4.5\text{V}$ Note 5, Fig. 1.2							
Logic low output voltage	$V_{OL}$	$I_F=16\text{mA}, I_O=1.1\text{mA}, V_{CC}=4.5\text{V}$				0.1	0.4		V
		$I_F=16\text{mA}, I_O=2.4\text{mA}, V_{CC}=4.5\text{V}$		0.1	0.4				
		$I_F=8\text{mA}, I_O=0.7\text{mA}, V_{CC}=4.5\text{V}$							
Logic high output current	$I_{OH}$	$I_F=0\text{mA}, V_O=V_{CC}=5.5\text{V}, T_A=25^\circ\text{C}$		.003	*.5		.003	*.5	$\mu\text{A}$
		$I_F=0\text{mA}, V_O=V_{CC}=15\text{V}, T_A=25^\circ\text{C}$		0.01	1		0.01	1	
		$I_F=0\text{mA}, V_O=V_{CC}=15\text{V}$ Fig. 7			50			50	
Logic low supply current	$I_{CCL}$	$I_F=16\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}$		40			40		$\mu\text{A}$
		$I_F=8\text{mA}, V_O=\text{Open}, V_{CC}=5.5\text{V}$							
Logic high supply current	$I_{CCH}$	$I_F=0\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}, T_A=25^\circ\text{C}$		0.02	*1		0.02	*1	$\mu\text{A}$
		$I_F=0\text{mA}, V_O=\text{Open}, V_{CC}=15\text{V}$			2			2	
Input forward voltage	$V_F$	$I_F=16\text{mA}, T_A=25^\circ\text{C}$		1.5	1.7		1.5	1.7	V
		$I_F=8\text{mA}, T_A=25^\circ\text{C}$ Fig. 3							
Input reverse breakdown voltage	$BV_R$	$I_F=10\mu\text{A}, T_A=25^\circ\text{C}$	*5			*5			V
Temp. coefficient of forward voltage	$V_F$	$I_F=16\text{mA}$		-1.6			-1.6		$\text{mV}/^\circ\text{C}$
Input-Output insulation leakage	$I_{I-O}$	45% Relative Humidity $t=5\text{sec}$ $V_{I-O}=3000\text{V}_{DC}, T_A=25^\circ\text{C}$ Note 6			*1.0			*1.0	$\mu\text{A}$
Withstand insulation test voltage	$V_{ISO}$	$RH \leq 50\% t = 1\text{min}$ $T_A=25^\circ\text{C}$ Notes 6, 11, 12	2500			2500			V RMS
Resistance (Input-Output)	$R_{I-O}$	$V_{I-O}=500\text{V}_{DC}$ Note 6		$10^{12}$			$10^{12}$		$\Omega$
Capacitance (Input-Output)	$C_{I-O}$	$F=1\text{MHz}$ Note 6		0.6			0.6		pF
DC current gain	$h_{FE}$	$I_O=3\text{mA}, V_O=5\text{V}$		150			150		—

\*JEDEC Registered Data  
All typical values are at  $T_A=25^\circ\text{C}$

**SWITCHING CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  Unless Otherwise Specified)  $V_{CC} = 5.0\text{V}$

PARAMETER	SYMBOL	TEST CONDITIONS	MCL2501			MCL/HCPL-2503			MCL/HCPL-2502			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Propagation delay time to logic low at output	$t_{PHL}$	$I_F = 16\text{mA}, R_L = 4.1\text{K}$										$\mu\text{s}$
		$I_F = 16\text{mA}, R_L = 1.9\text{K}$							.35	0.8		
		$I_F = 16\text{mA}, R_L = 1.9\text{K}, 0-70^\circ\text{C}$	.35	0.8								
		$I_F = 16\text{mA}, R_L = 4.7\text{K}$				0.4	1.5					
		$I_F = 8\text{mA}, R_L = 7.5\text{K}$				1.0	1.5					
Propagation delay time to logic high at output	$t_{PLH}$	$I_F = 16\text{mA}, R_L = 4.1\text{K}$								.25	0.8	$\mu\text{s}$
		$I_F = 16\text{mA}, R_L = 1.9\text{K}$										
		$I_F = 16\text{mA}, R_L = 1.9\text{K}, 0-70^\circ\text{C}$	.20	.35								
		$I_F = 16\text{mA}, R_L = 4.7\text{K}$				1.5	2.5					
		$I_F = 8\text{mA}, R_L = 7.5\text{K}$				1.5	2.5					
Common mode transient immunity at logic high output level	$CM_H$	$V_{CM} = 10V_p, R_L = 4.1\text{K}$										$V/\mu\text{s}$
		$V_{CM} = 10V_p, R_L = 1.9\text{K}$							10K			
		$V_{CM} = 10V_p, R_L = 4.7\text{K}$				10K						
		$V_{CM} = 50V_p, R_L = 1.9\text{K}$ Notes 7, 8, 9 Fig. 11	1K	10K								
		$V_{CM} = 50V_p, R_L = 1.9\text{K}$ Notes 7, 8, 9 Fig. 11										
Common mode transient immunity at logic low output level	$CM_L$	$V_{CM} = 10V_p, R_L = 4.1\text{K}$										$V/\mu\text{s}$
		$V_{CM} = 10V_p, R_L = 1.9\text{K}$							-10K			
		$V_{CM} = 10V_p, R_L = 4.7\text{K}$				-10K						
		$V_{CM} = 50V_p, R_L = 1.9\text{K}$ Notes 7, 8, 9 Fig. 11	-1K	-10K								
		$V_{CM} = 50V_p, R_L = 1.9\text{K}$ Notes 7, 8, 9 Fig. 11										
Bandwidth	BW	$R_L = 100$ Note 10 Fig. 10		3			2			2		MHz

\*JEDEC Registered Data

**ABSOLUTE MAXIMUM RATINGS†**

Storage temperature .....  $-55^\circ\text{C}$  to  $125^\circ\text{C}$   
 Operating temperature .....  $-55^\circ\text{C}$  to  $100^\circ\text{C}$   
 Lead solder temperature .....  $260^\circ\text{C}$  for 10s  
 Average forward input current ..... 25 mA (1)  
 Peak forward input current ..... 50 mA (2)  
 (50% duty cycle, 1ms P.W.)  
 Peak transient input current -  $I_F$  ..... 1.0 A  
 ( $\leq 1\ \mu\text{s}$  P.W., 300 pps)

Reverse input voltage ..... 5 V  
 Input power dissipation ..... 45 mW (3)  
 Average output current ..... 8 mA  
 Peak output current ..... 16 mA  
 Emitter-base reverse voltage ..... 5 V  
 Supply and output voltage .....  $-0.5\text{V}$  to 15 V  
 Base current ..... 5 mA  
 Output power dissipation ..... 100 mW(4)

†Absolute Maximum Ratings are JEDEC Registered Data for 6N136 and 6N135.  
 6N136 and 6N135 are the only JEDEC Registered Parts on this data sheet.

**SWITCHING CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  Unless Otherwise Specified)  $V_{CC} = 5.0\text{ V}$

PARAMETER	SYMBOL	TEST CONDITIONS	6N136			6N135			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Propagation delay time to logic low at output	$t_{PHL}$	$I_F=16\text{mA}, R_L=4.1\text{K}$					0.5	*1.5	$\mu\text{s}$
		$I_F=16\text{mA}, R_L=1.9\text{K}$		0.35	*0.8				
		$I_F=16\text{mA}, R_L=1.9\text{K}$							
		$I_F=16\text{mA}, R_L=4.7\text{K}$							
		$I_F=8\text{mA}, R_L=7.5\text{K}$							
		$I_F=8\text{mA}, R_L=7.5\text{K}$ Notes 8, 9 Fig. 12							
Propagation delay time to logic high at output	$t_{PLH}$	$I_F=16\text{mA}, R_L=4.1\text{K}$					0.4	*1.5	$\mu\text{s}$
		$I_F=16\text{mA}, R_L=1.9\text{K}$		.25	*0.8				
		$I_F=106\text{mA}, R_L=1.9\text{K}$							
		$I_F=16\text{mA}, R_L=4.7\text{K}$							
		$I_F=8\text{mA}, R_L=7.5\text{K}$							
		$I_F=8\text{mA}, R_L=7.5\text{K}$ Notes 8, 9 Fig. 12							
Common mode transient immunity at logic high output level	$CM_H$	$V_{CM}=10V_p, R_L=4.1\text{K}$				1K	10K		$\text{V}/\mu\text{s}$
		$V_{CM}=10V_p, R_L=1.9\text{K}$	1K	10K					
		$V_{CM}=10V_p, R_L=4.7\text{K}$							
		$V_{CM}=50V_p, R_L=1.9\text{K}$ Notes 7, 8, 9 Fig. 11	1K	10K					
Common mode transient immunity at logic high output level	$CM_L$	$V_{CM}=10V_p, R_L=4.1\text{K}$				-1K	-10K		$\text{V}/\mu\text{s}$
		$V_{CM}=10V_p, R_L=1.9\text{K}$	-1K	-10K					
		$V_{CM}=10V_p, R_L=4.7\text{K}$							
		$V_{CM}=50V_p, R_L=1.9\text{K}$ Notes 7, 8, 9 Fig. 11	-1K	-10K					
Bandwidth	BW	$R_L=100$ Note 10 Fig. 10		2			2		MHz

\*JEDEC Registered Data

**NOTES:**

- Derate linearly above  $70^\circ\text{C}$  free-air temperature at a rate of  $0.8\text{ mA}/^\circ\text{C}$ .
- Derate linearly above  $70^\circ\text{C}$  free-air temperature at a rate of  $1.6\text{ mA}/^\circ\text{C}$ .
- Derate linearly above  $70^\circ\text{C}$  free-air temperature at a rate of  $0.9\text{ mW}/^\circ\text{C}$ .
- Derate linearly above  $70^\circ\text{C}$  free-air temperature at a rate of  $1.0\text{ mW}/^\circ\text{C}$ .
- CURRENT TRANSFER RATIO is defined as the ratio of output collector current,  $I_O$ , to the forward LED input current,  $I_F$ , times 100%.
- Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
- Common mode transient immunity in Logic High level is the maximum tolerable (positive)  $dV_{CM}/dt$  on the leading edge of the common mode pulse  $V_{CM}$ , to assure that the output will remain in a Logic High state (i.e.,  $V_O > 2.0\text{ V}$ ). Common mode transient immunity in Logic Low level is the maximum tolerable (negative)  $dV_{CM}/dt$  on the trailing edge of the common mode pulse signal,  $V_{CM}$  to assure that the output will remain in a Logic Low state (i.e.,  $V_O < 0.8\text{ V}$ ).
- The  $4.1\text{ K}\Omega$  load represents 1 LSTTL unit load of  $0.36\text{ mA}$  and  $6.1\text{ K}\Omega$ .
- The  $1.9\text{ K}\Omega$  load represents 1 TTL unit load of  $1.6\text{ mA}$  and the  $5.6\text{ K}\Omega$  pull-up resistor.
- The frequency at which the ac output voltage is 3 dB below the low frequency asymptote.
- This is a proof test to validate the UL440 VAC rating.
- The  $2500\text{ Vac}/\text{min}$  capability is validated by a factory  $3.1\text{K Vac (rms)}/1\text{ sec}$  dielectric voltage withstand test.

Optocouplers

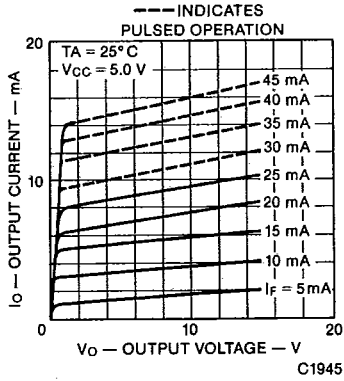


Fig. 1. DC and Pulsed Transfer Characteristics

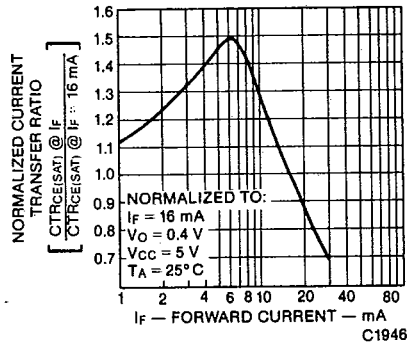


Fig. 2. Normalized Current Transfer Ratio vs. Forward Current

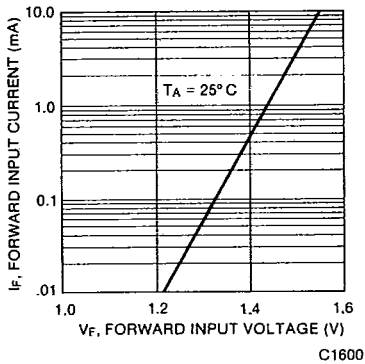


Fig. 3. Forward Input Current vs. Forward Input Voltage

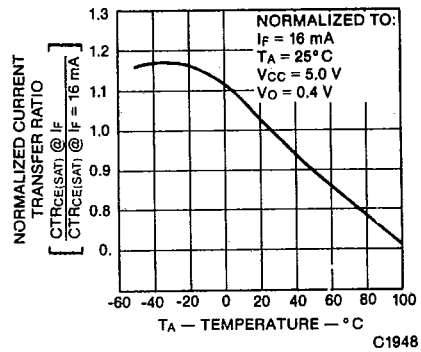


Fig. 4. Normalized Current Transfer Ratio vs. Temperature

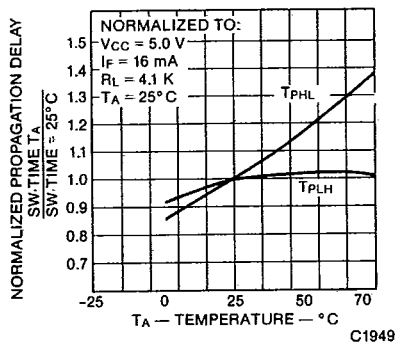


Fig. 5. Normalized Propagation Delay vs. Temperature at  $I_F = 16\text{ mA}$

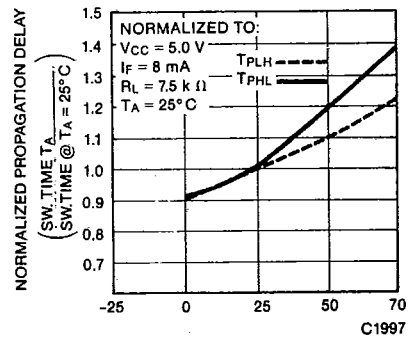


Fig. 6. Normalized Propagation Delay vs. Temperature at  $I_F = 8\text{ mA}$

## TYPICAL CHARACTERISTIC CURVES (T<sub>A</sub> = 25°C Unless Otherwise Specified)

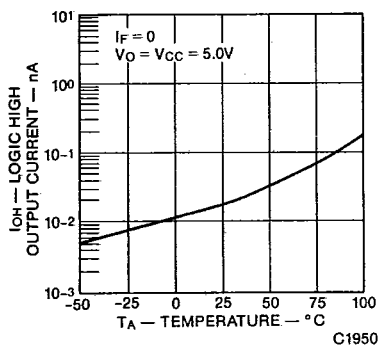


Fig. 7. Logic High Output Current vs. Temperature

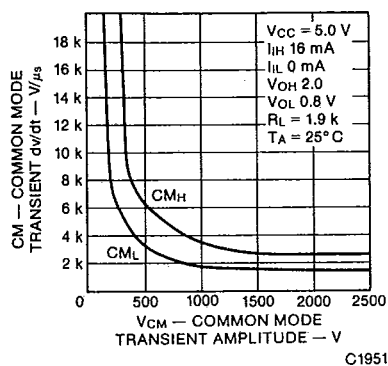


Fig. 8. Common Mode Transient Immunity vs. Common Mode Transient Amplitude

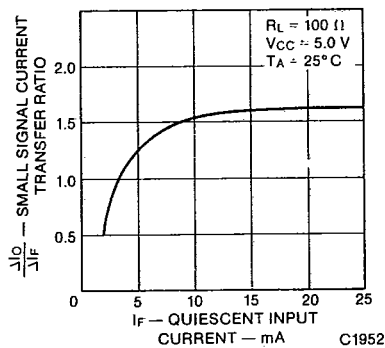


Fig. 9. Small Signal Transfer Ratio vs. Quiescent Input Current

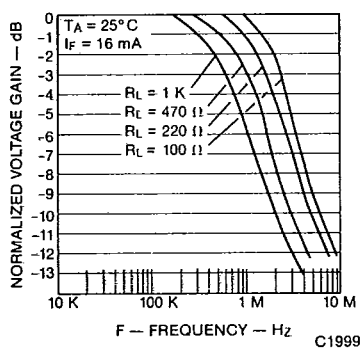
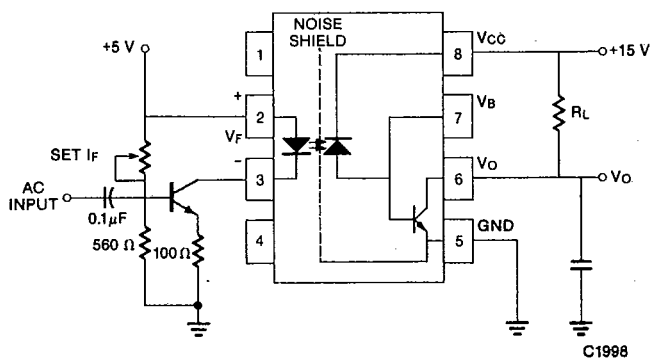


Fig. 10. Frequency Response



## TYPICAL CHARACTERISTIC CURVES ( $T_A = 25^\circ\text{C}$ Unless Otherwise Specified)

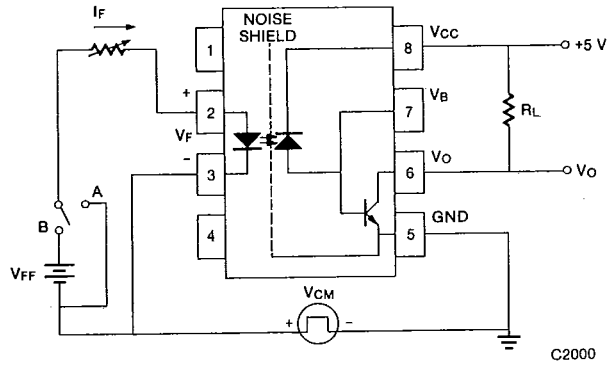
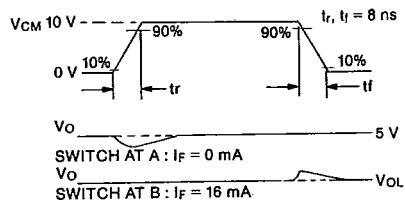


Fig. 11. Test Circuit for Transient Immunity and Typical Waveforms

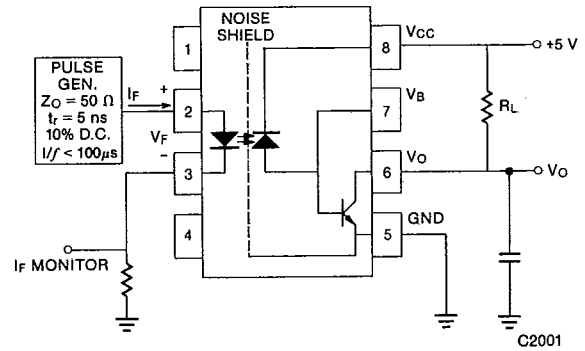
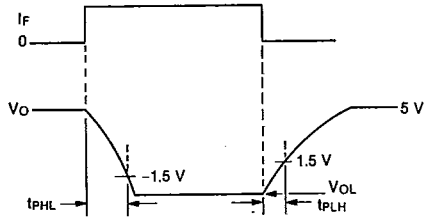


Fig. 12. Switching Test Circuit