National Semiconductor

LH0082 Optical Communication Receiver

General Description

The LH0082 is a general purpose, low-noise, fiber optic receiver, which may also be used as a fast current to voltage converter, or as a high speed voltage amplifier. The circuit includes a 2GHz gain-bandwidth FET-input amplifier, a 2.4 volt reference, a comparator with hysteresis, and all the necessary resistors and capacitors for feedback and coupling, all integrated in a hermetic dual-in-line package. The large gain-bandwidth of the preamp enables fast response even with high capacitance photodiodes. A separate analog output permits the reception of analog signals to 20MHz via a fiber optic link. The internal comparator converts a low level analog signal to a CMOS/TTL/DTL compatible logic signal at data rates up to 15Mbits/s NRZ. The LH0082 can be used with an external comparator at data rates to 50Mbits/s.

Features

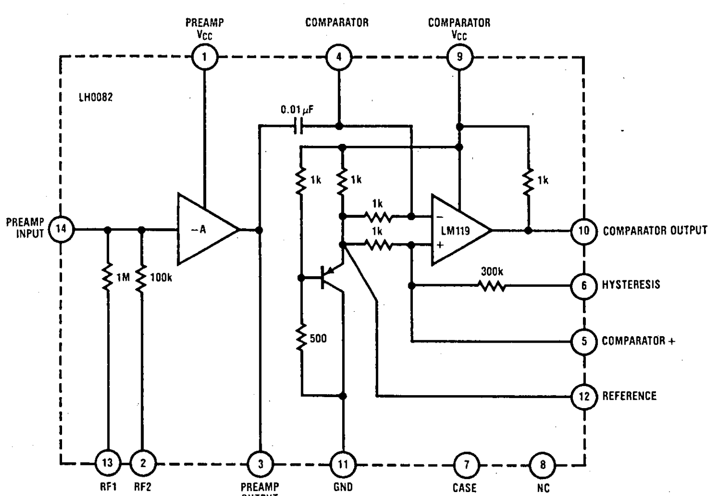
- Single 4.5 to 12 Volt Supply
- DC to 50 Mbits/s NRZ Data Bandwidth
- Low Noise
- $< 10^{-9}$ Bit Error Rate
- Low Input Bias Current
- Pin Selectable Sensitivity: −45dBm/−35dBm*
- CMOS/TTL/DTL Compatibility
- Can be used with photodiodes, PIN photodiodes, phototransistors, avalanche photodiodes, and photomultipliers
- Hermetic Dual In Line Metal Package
- Highly Versatile Building Block
- > 45dB Dynamic Range

*Assumes 0.5A/W PIN diode input

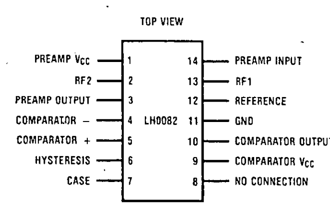
Applications

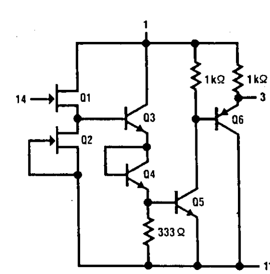
- Data Terminals
- Secure Communication
- Peripheral Control/Communication
- Video Transmission
- Wideband Amplifier
- High Speed Current to Voltage Converter
- Fiber-Optic Repeater
- Video Amplifier
- Industrial Machine Control

LH0082 Schematic Diagram



Connection Diagram





Order Number LH0082D or LH0082CD See Package D14F

Absolute Maximum Ratings

Supply Voltage	+15V
Power Dissipation, $T_A = 25°C$	0.5W
Junction Temperature	150°C
Storage Temperature	−65°C to +150°C
Operating Temperature Range	
LH0082D	−55°C to 125°C
LH0082CD	−25°C to 85°C
Lead Temperature (Soldering, 20 Seconds)	300°C
Input Voltage	$V_{CC} - 20 < V_{IN} < V_Q$

Electrical Characteristics Preamplifier: Power supply voltage = $+5V_{DC}$, $T_A = 25°C$, see Figure 1

	Parameter	Min.	Typ.	Max.	Units
I_B	Input Bias Current		100		pA
C_{IN}	Input Capacitance			5	pF
A_V	Voltage Gain		90		V/V
f_{3dB}	−3dB Frequency		18		MHz
V_Q	Output Quiescent Voltage	1.9	2.1	2.6	V
$\Delta V_Q/\Delta T$	Output Quiescent Voltage Drift with Temperature		−6		mV/°C
Z_O	Open Loop Output Impedance at 1 MHz		30		Ω
	Output Noise (10 Hz to 10 MHz)		300		μV RMS
V_O	Output Swing (No Load)	3.5	4.0		V_{P-P}
	Transimpedance:				
	Low Sensitivity	90	100	110	kΩ
	High Sensitivity	0.9	1	1.1	MΩ
I_S	Supply Current		22	30	mA

Electrical Characteristics Comparator/Reference: Power supply voltage = $+5V_{DC}$, $T_A = 25°C$, see Figure 2

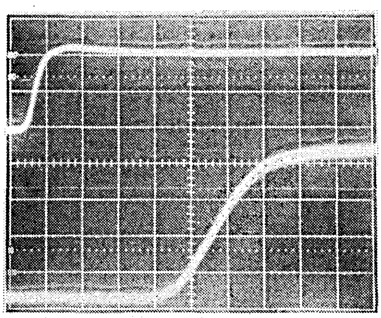
	Parameter	Min.	Typ.	Max.	Units
R_{IN}	Comparator Input Resistance (to reference)	0.95	1	1.05	kΩ
V_{HYST}	Hysteresis Voltage				
	Positive	7	8.7	11.4	mV
	Negative	5	6.9	8.8	mV
R_O	Output Pullup Resistor	0.95	1	1.05	kΩ
V_R	Reference Voltage	2.2	2.4	2.6	V
$\Delta V_R/\Delta T$	Reference Voltage Drift with Temperature		−2		mV/°C
R_O (V_{REF})	Reference Voltage Output Resistance		15		Ω
V_{OL}	($I_{OL} = 3.2mA$)		0.3	0.5	V
V_{OH}	($I_{OH} = -1mA$)	3.8	4		V
T_{PD}	($V_{IN} = 30mV$, $V_{OD} = 15mV$)		160		ns
T_R	($C_L = 3pF$)		80		ns
T_F	($C_L = 3pF$)		60		ns
I_S	Supply Current:				
	Output High	4.5	8	17	mA
	Output Low	9.5	13	22	mA

Electrical Characteristics Fiber Optic Receiver:

Photodiode responsivity is assumed to be 0.5 A/W, capacitance of 10 pF at 2.5V reverse bias, $V_{CC} = 5V$, $T_A = 25°C$, $C_L = 15\,pF$

	Parameter	Min.	Typ.	Max.	Units
	High Sensitivity: $R_F = 1\,M\Omega$, see Figure 3.				
	Input Power for 10^{-9} BER (bit rate = 500 Kbit NRZ)		30		nW
t_r, t_f	Analog Output Rise or Fall Time		1.5		μs
	Maximum Data Rate, NRZ, Digital Output		650		Kbit/s
P_N	Noise Equivalent Power		1		nW
i_N	Equivalent Input Noise Current (10 Hz to 10 MHz)		300		pA RMS
	Low Sensitivity: $R_F = 100\,K\Omega$, see Figure 4				
	Input Power for 10^{-9} BER (bit rate = 2 Mbit NRZ)		300		nW
t_r, t_f	Analog Output Rise or Fall Time		50		ns
	Maximum Data Rate, NRZ, Digital Output		5		Mbit/s
P_N	Noise Equivalent Power		10		nW
i_N	Equivalent Input Noise Current (10 Hz to 10 MHz)		3		nA RMS
I_S	Total Supply Current (High or Low Sensitivity)		35		mA

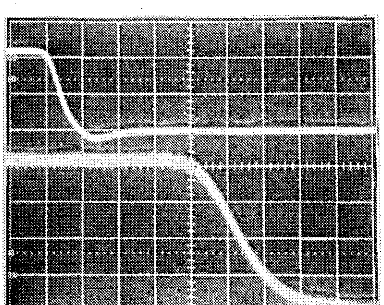
Fiber optic receiver preamp response
$R_F = 100\,k\Omega$
Photodiode capacitance = 10 pF, $V_{CC} = 5V$



Optical Input

Preamp output (20 mV/div) (Pin 3)

Time (10 ns/div)

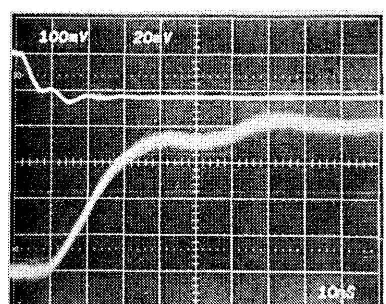


Optical Input

Preamp output (20 mV/div)

Time (10 ns/div)

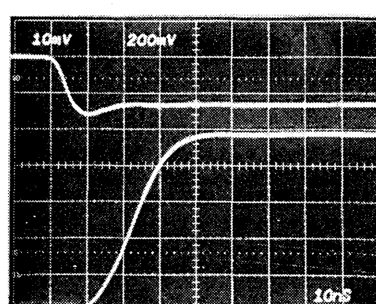
Preamp Voltage Mode Pulse Response



Input (10 mV/div)

Output (200 mV/div) (Pin 3)

Small Signal



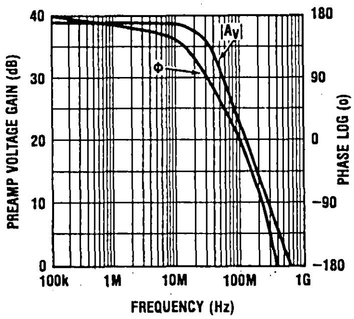
Input (10 mV/div)

Output (200 mV/div)

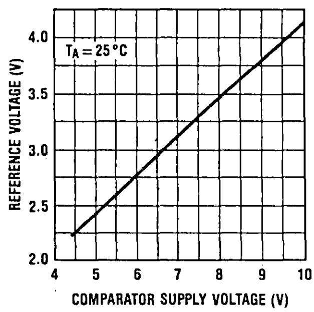
Large Signal

Typical Performance Characteristics

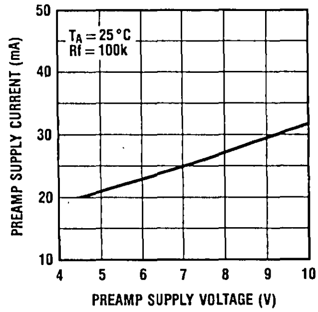
Open Loop Voltage Gain



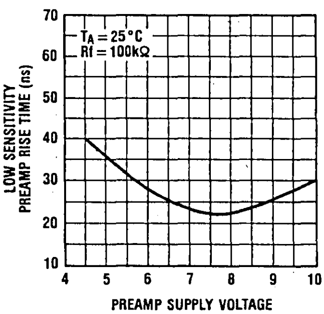
Reference Voltage



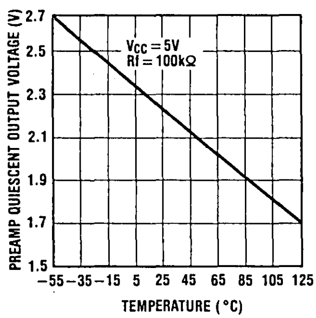
Supply Current



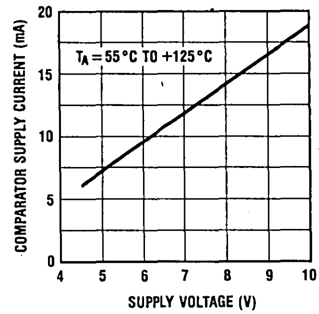
Response Time



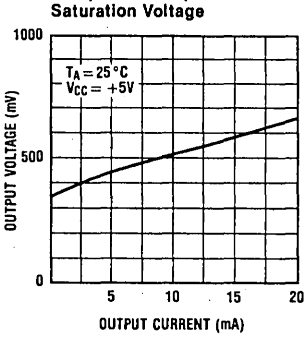
Output Voltage



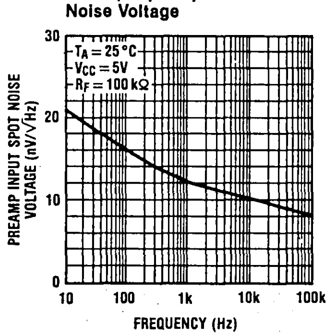
Comparator Supply Current (Output High)



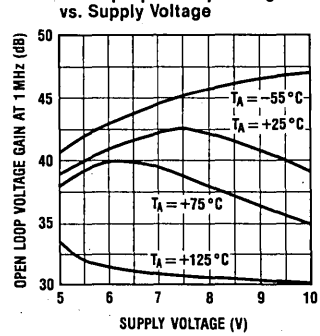
Comparator Output Saturation Voltage



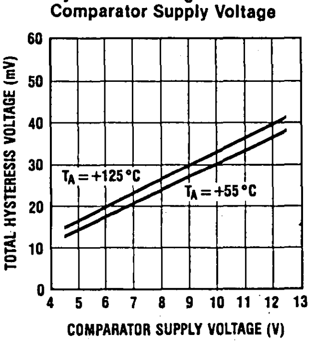
Preamp Input Spot Noise Voltage



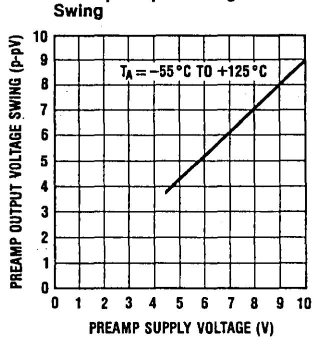
Preamp Open Loop Voltage vs. Supply Voltage



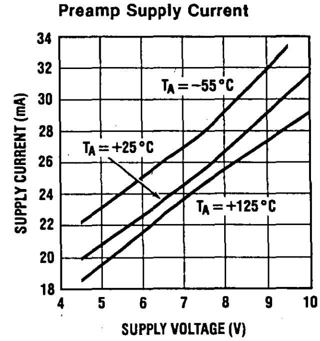
Hysteresis Voltage vs. Comparator Supply Voltage



Preamp Output Voltage Swing



Preamp Supply Current



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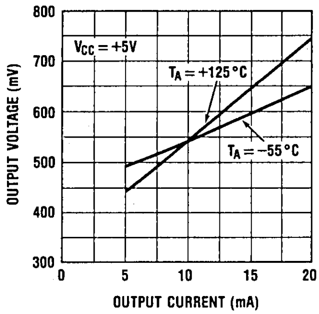
Comparator Output Saturation Voltage



Applications Information

The gain-bandwidth of the LH0082 preamp is nearly 2GHz, thus good bypassing of the supply voltage is necessary; a 3.3μF tantalum capacitor in parallel with a 0.01μF ceramic disc is recommended, placed as close as possible to the device pins.

Careful shielding of pins 2, 13, and 14 is necessary if the LH0082 is used in a high noise environment. Minimize stray capacitance to pin 14 from ground, V_{CC} or pin 3 to avoid slowing overall circuit response. Choose the lowest capacitance photodiode possible for the application. When using phototransistors, only the collector-base junction should be used for fastest response. Additional sensitivity may be gained by using a phototransistor in the transistor mode, although this will result in slower circuit response, and poor DC stability due to beta multiplication of the dark current of the phototransistor. Avoid capacitive loading at the output of the comparator to achieve maximum data rates.

Avalanche photodiodes can be used for improved sensitivity and speed. Overall speed is limited by the internal comparator. Use of an external comparator such as the LM160 will enable the full speed capability to be realized. This requires the use of an additional power supply, see Figure 8.

Increased speed of response may be realized in the high sensitivity mode by the addition of a resistor and a capacitor as shown in Figure 5. The resistor value may need to be adjusted to give a flat frequency response for differing circuit layouts. Figure 6 illustrates how very high sensitivity can be achieved by adding the desired feedback resistor.

The low sensitivity mode's speed of response may also be increased (as shown in Figure 7). A network must be added to the comparator to adjust for frequency dependent thresholds caused by the 0.01 coupling capacitor internal to the LH0082. Figure 8 shows the use of an external comparator to enable 50 Mbit data rates. Figures 9, 10, and 11 demonstrate interfacing techniques to avalanche photodiodes and phototransistors.

With a few additional components, the LH0082 can be used as a repeater as shown in Figure 12. Interfacing to a microcomputer-bus, (Figure 13), is also easy when the LH0082 is teamed with an INS8250 Asynchronous Communications Element. This provides a full duplex link capable of bit rates to 56Kbits/S.

Analog data can be sent along a fiber optic cable via digital means, (Figure 14), or by analog means and recovered as shown in Figure 7. Low temperature drift can be obtained in the analog mode, by using the circuit of Figure 15.

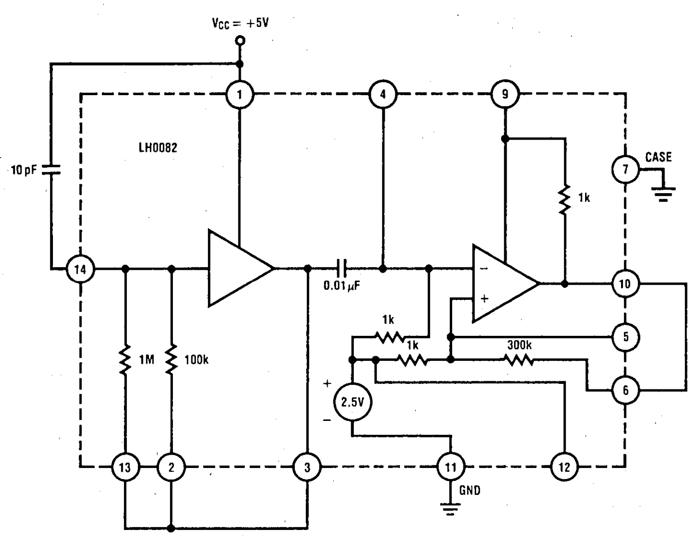


Figure 1. Preamp Test Circuit

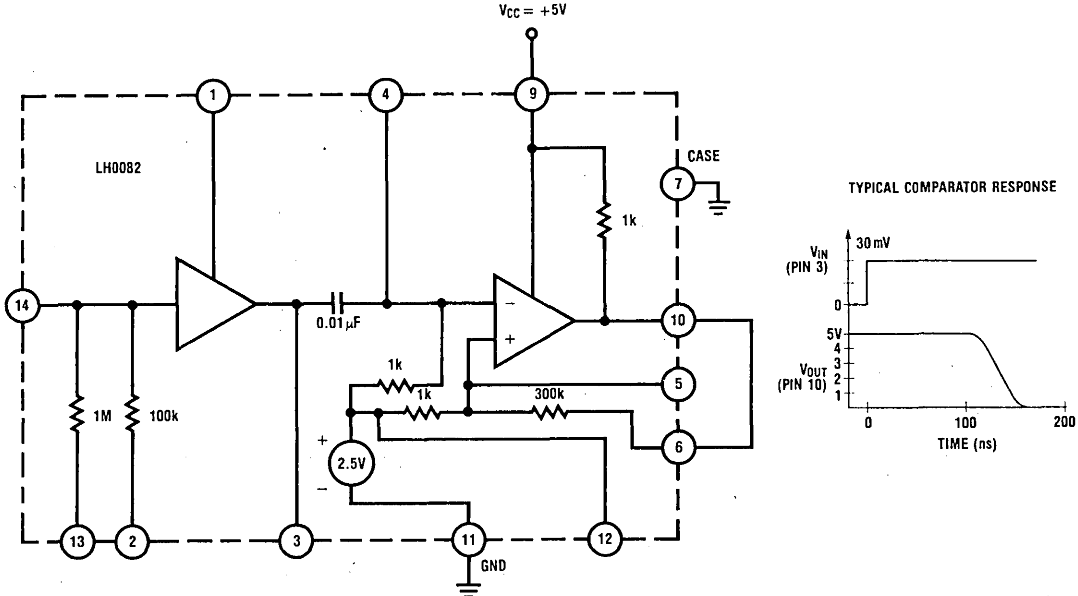


Figure 2. Comparator Test Circuit

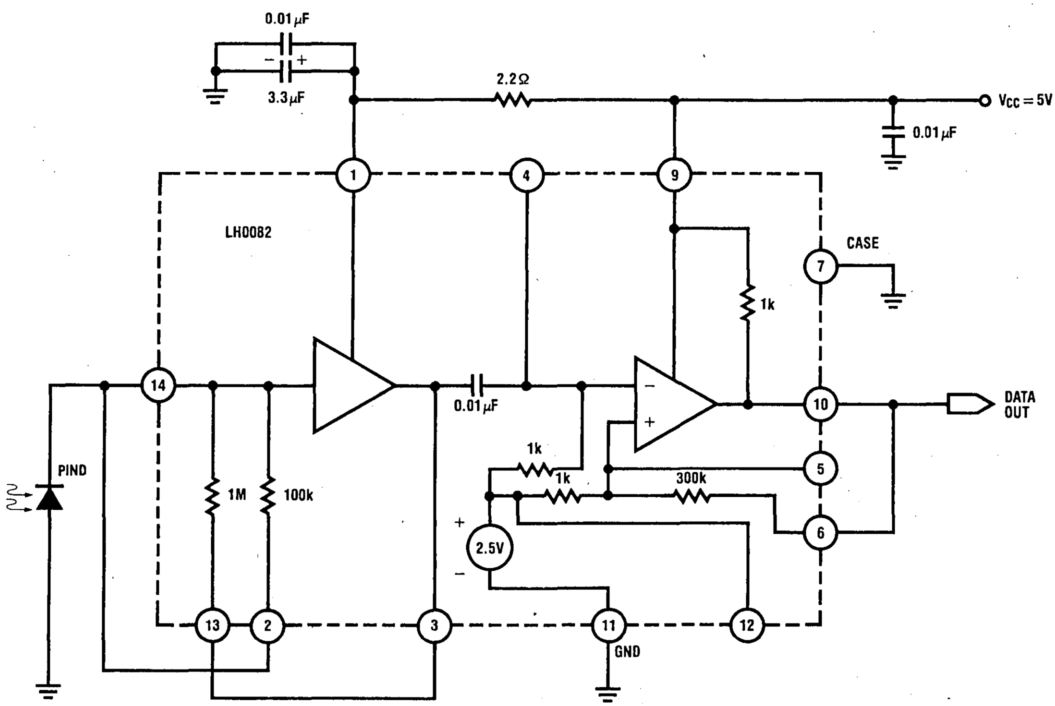


Figure 3. Fiber-Optic Receiver, Basic High Sensitivity: 30nW, 400kbps

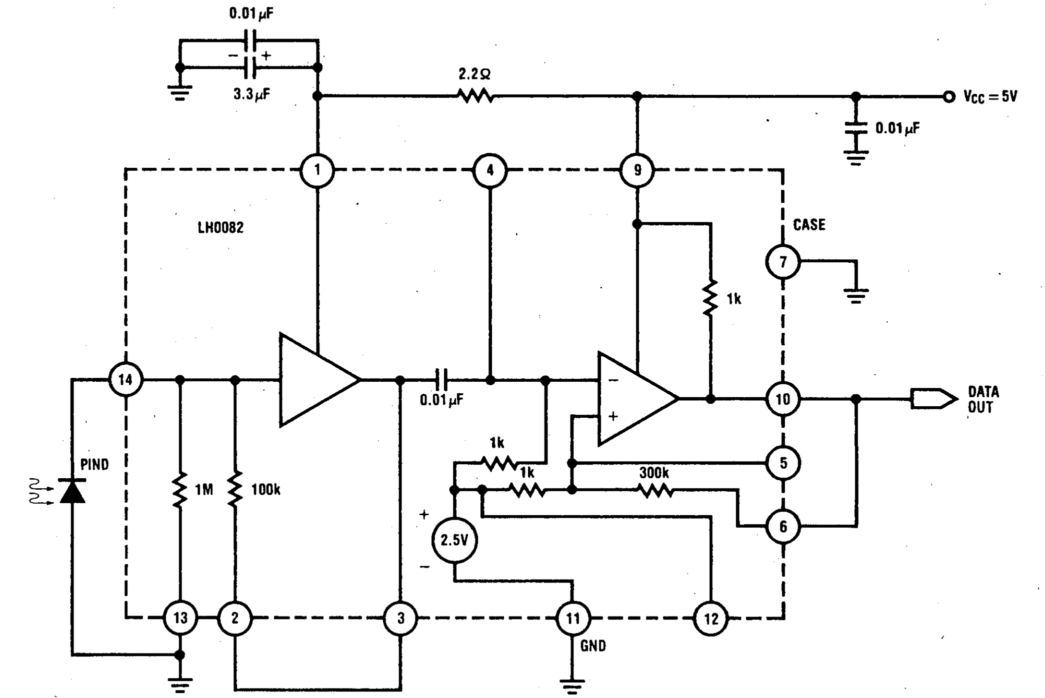


Figure 4. Fiber-Optic Receiver, Basic Low Sensitivity: 2μW, 5 Mbit

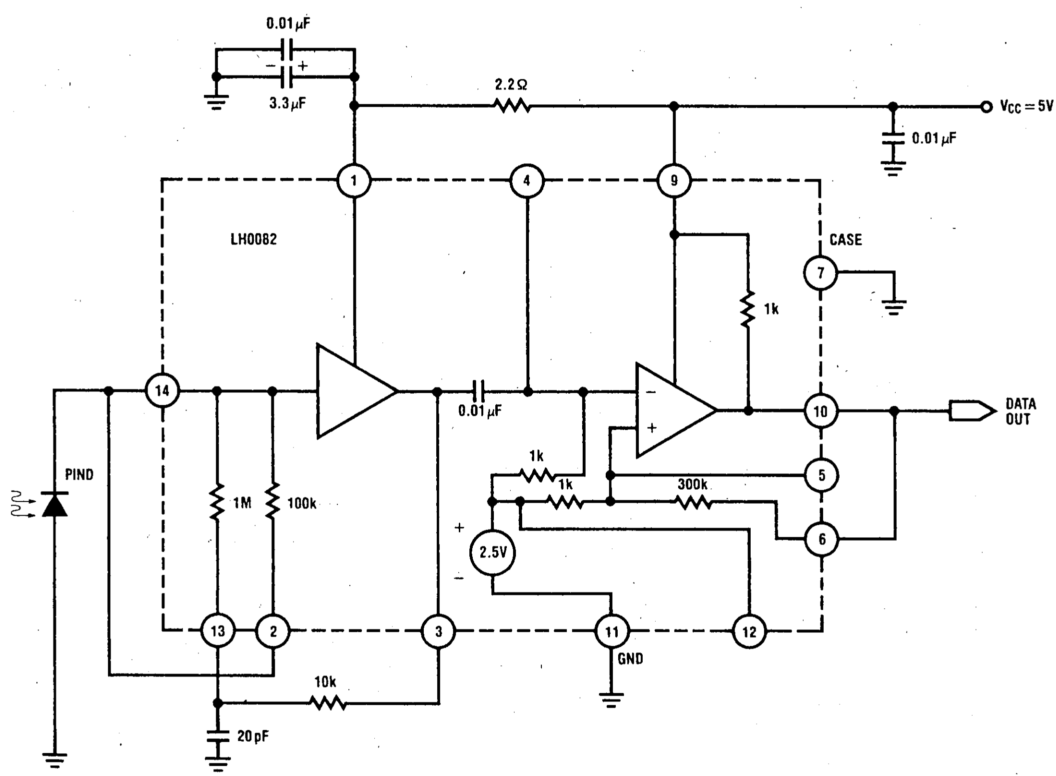


Figure 5. Fiber-Optic Receiver, High Sensitivity—Improved Speed

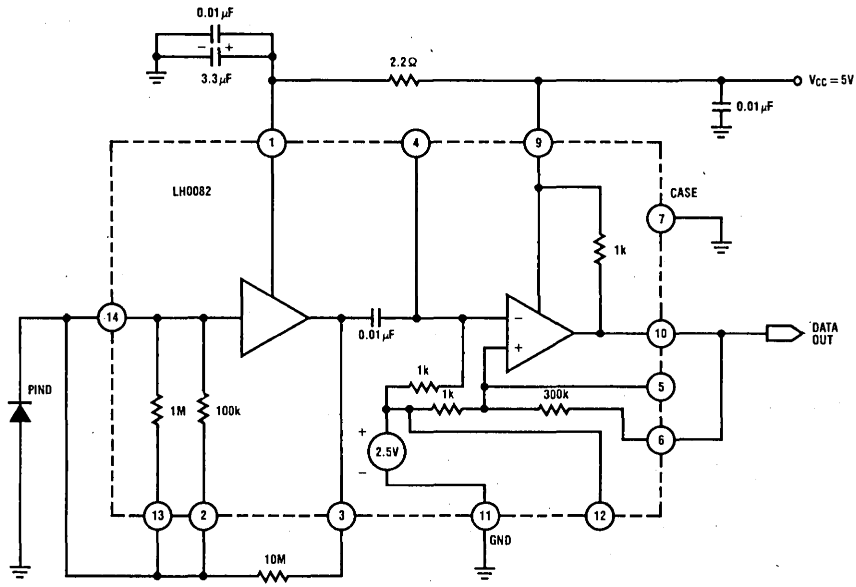
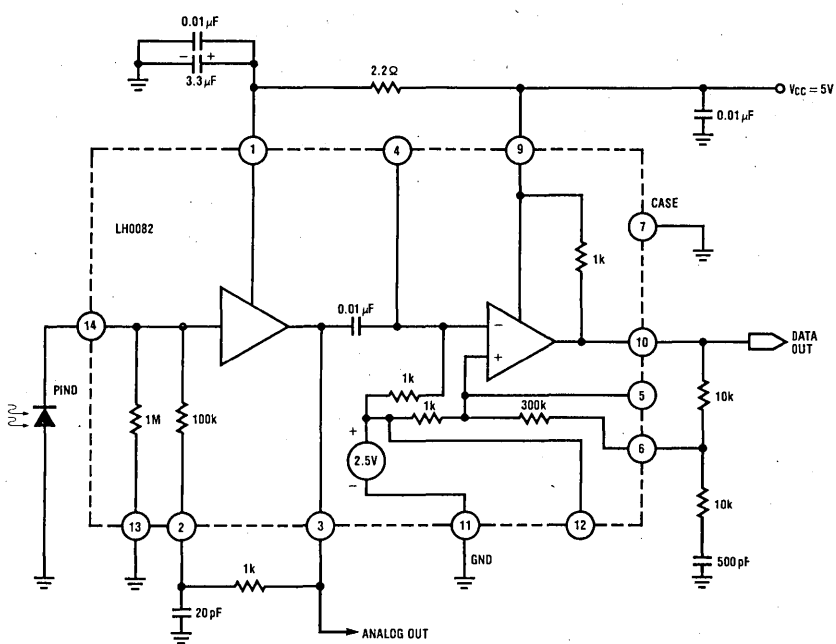
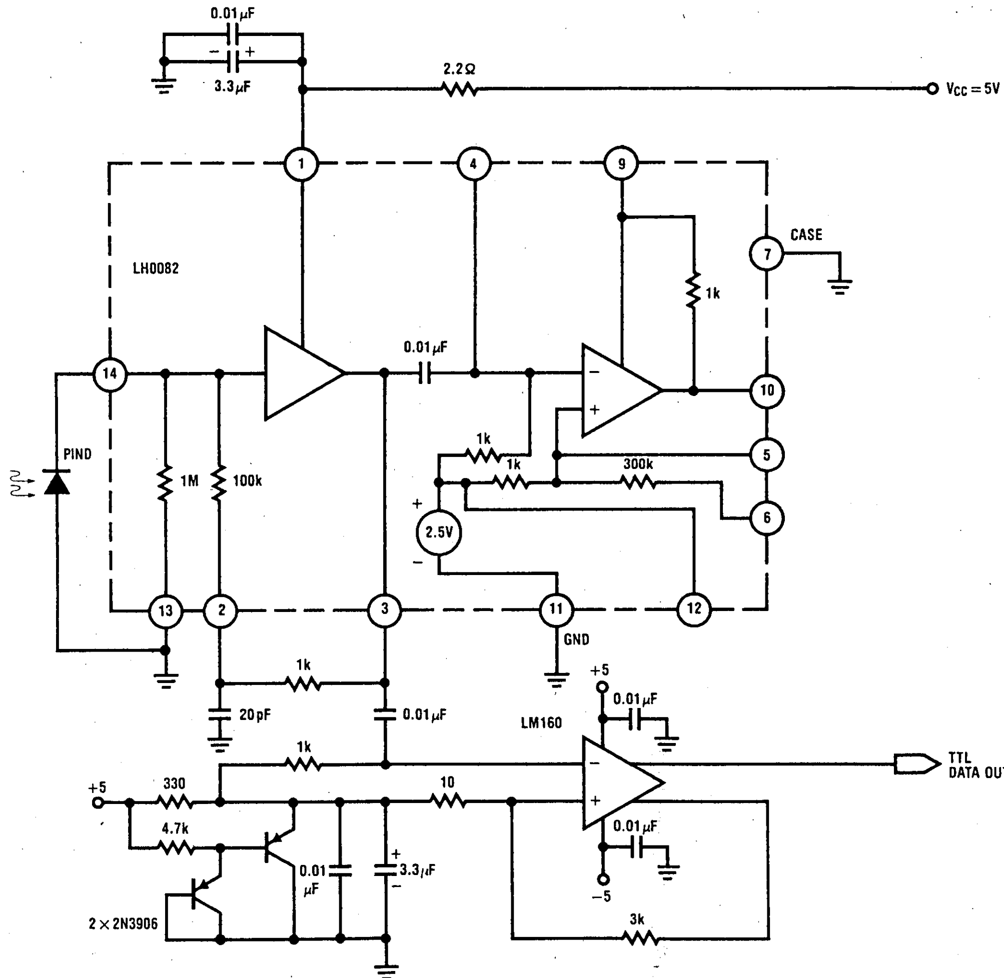


Figure 6. Fiber-Optic Receiver, Very High Sensitivity—Low Speed: 3nW



NOTE: FOR ANALOG OPERATION, USE THE CIRCUIT SHOWN IN FIGURE 7 WITH THE FOLLOWING MODIFICATIONS: DISCONNECT PIN 9 FROM V_{CC}, AND USE PIN 3 AS THE OUTPUT. BANDWIDTH FOR THIS CONFIGURATION IS APPROXIMATELY 20MHz. ANALOG RESPONSIVITY IS 50mV/μW. DYNAMIC RANGE IS 80dB.

Figure 7. 300nW Sensitivity



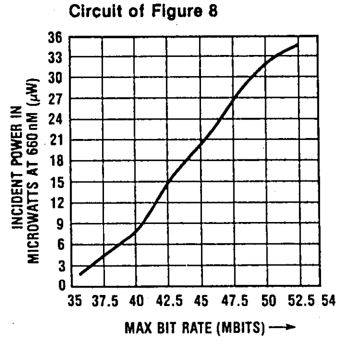


Figure 8. High Speed — Low Sensitivity Receiver

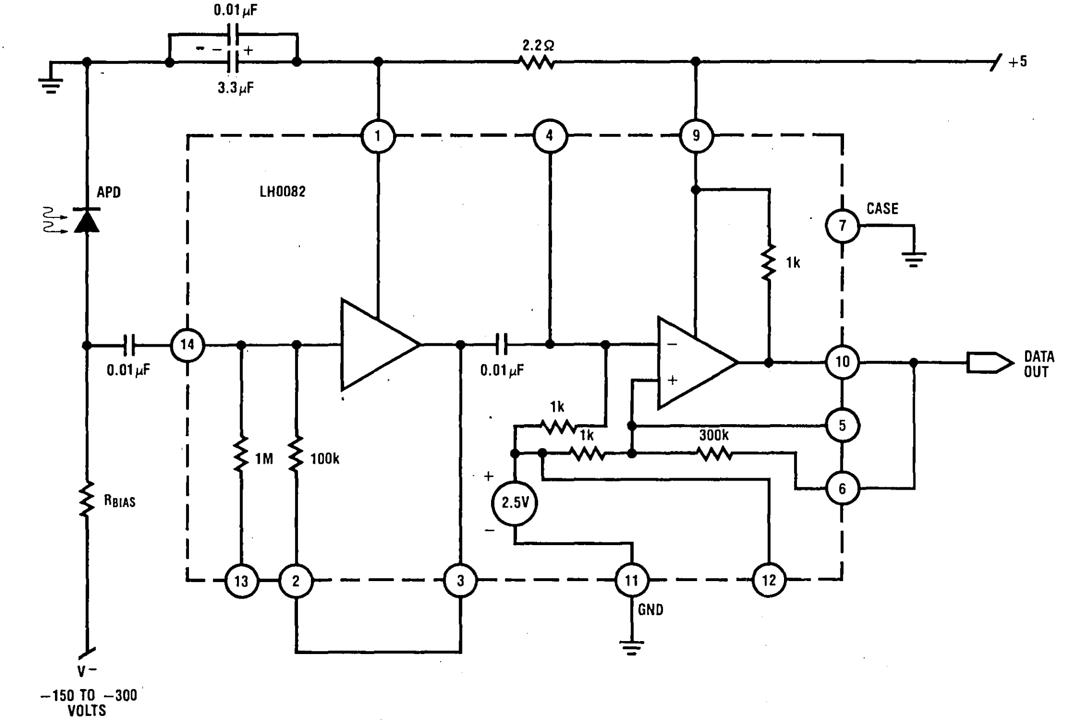


Figure 9. Connection to Avalanche Photodiode

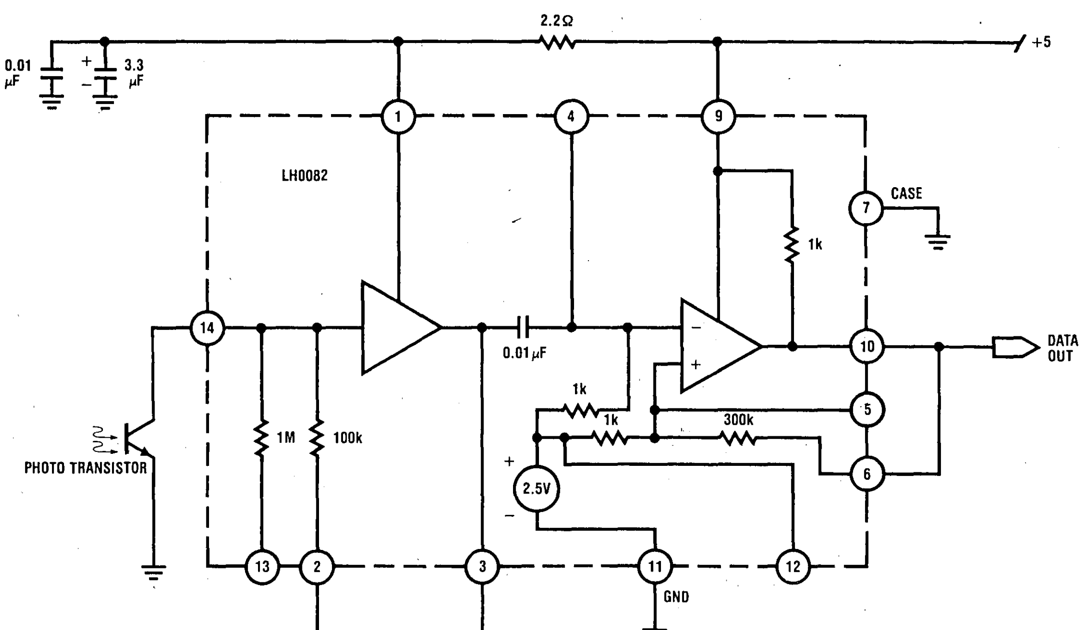


Figure 10. Connection to Phototransistor — High Sensitivity, Low Speed

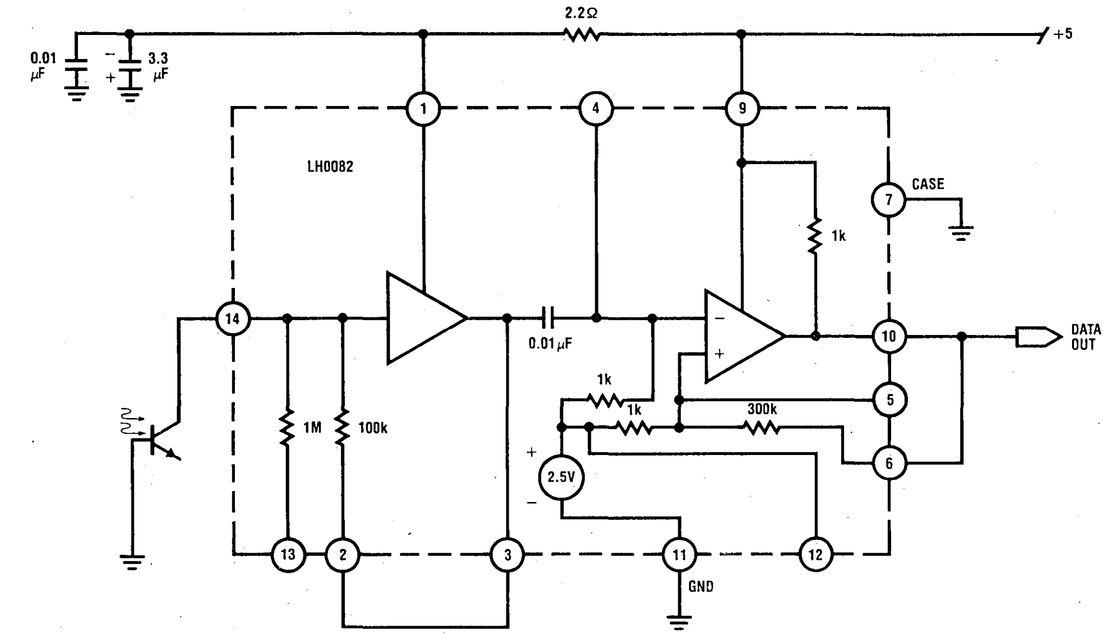


Figure 11. Connection to Phototransistor —
Low Sensitivity, High Speed Receiver

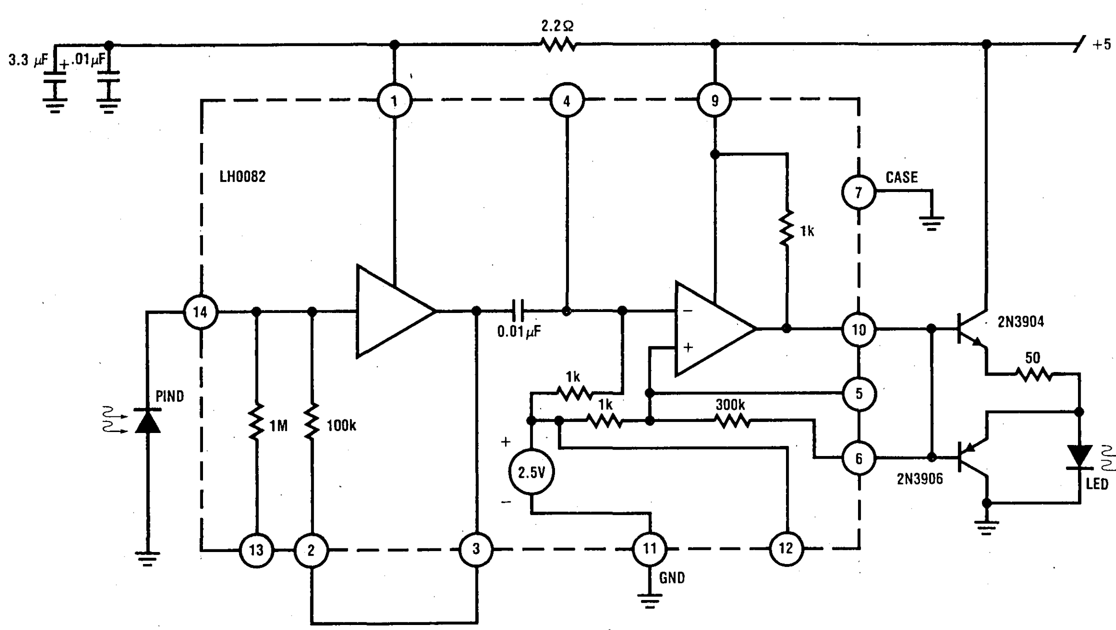


Figure 12. Fiber-Optic Link Repeater

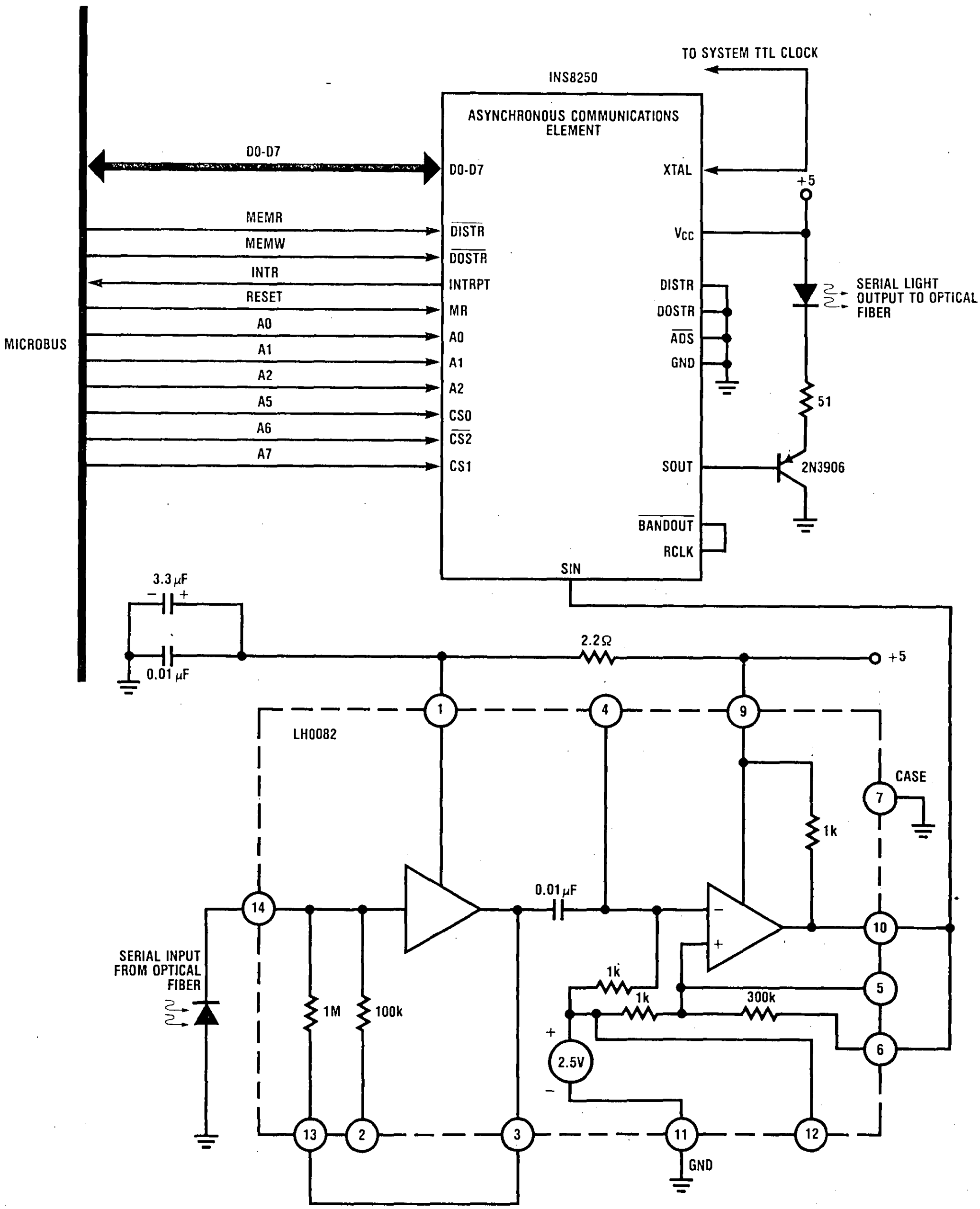


Figure 13. Optical Link to Microbus

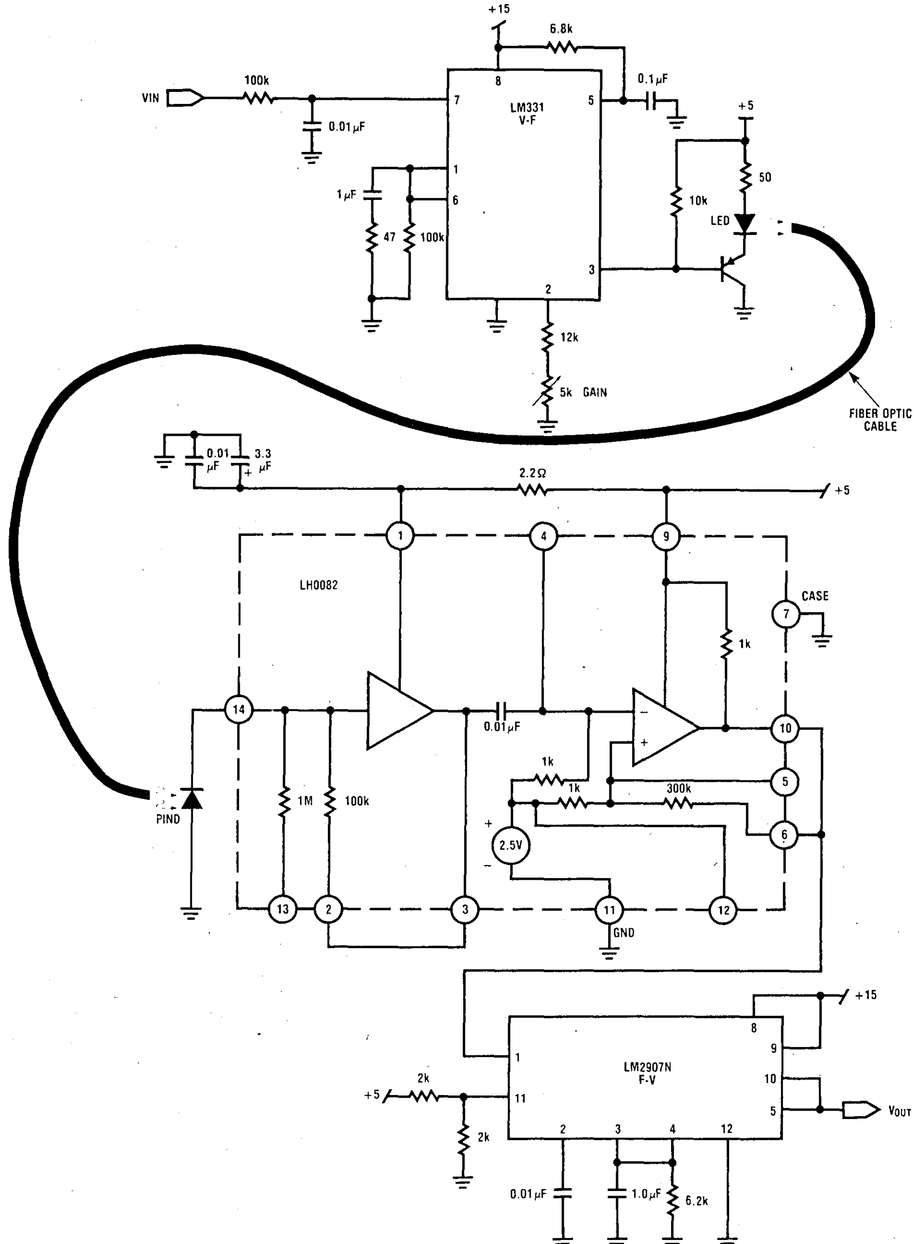


Figure 14. Analog Data Link Using V/F and F/V

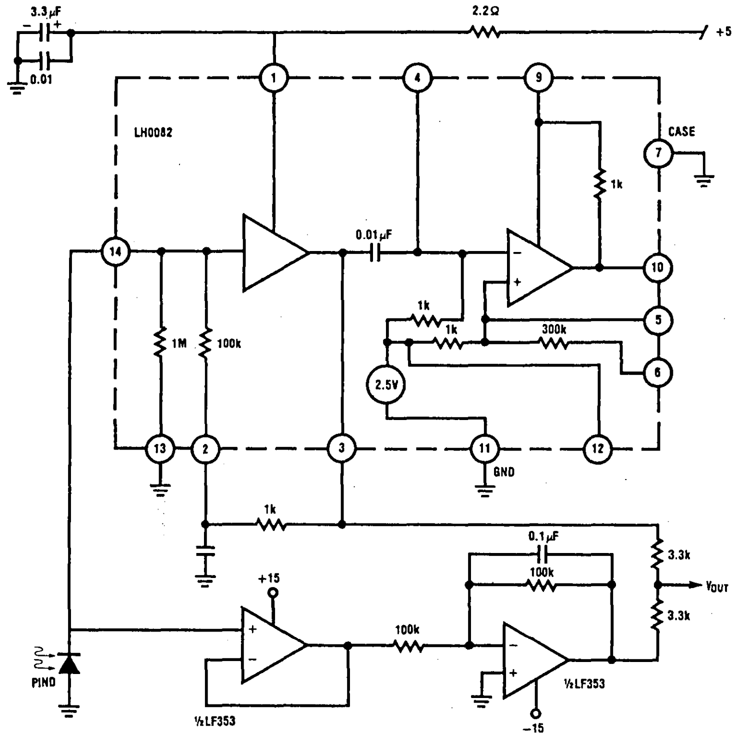


Figure 15. Low Temperature Drift Analog Receiver,