National Semiconductor

LH0082 Optical Communication Receiver/Amplifier

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 wide-bandwidth FET-input amplifier, a 2.4V 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 20 MHz via a fiber-optic link. The internal comparator converts a low level analog signal to a CMOS/TTL compatible logic signal at data rates up to 5 Mbits/s NRZ. The LH0082 can be used with an external comparator at data rates to 40 Mbits/s.

Features

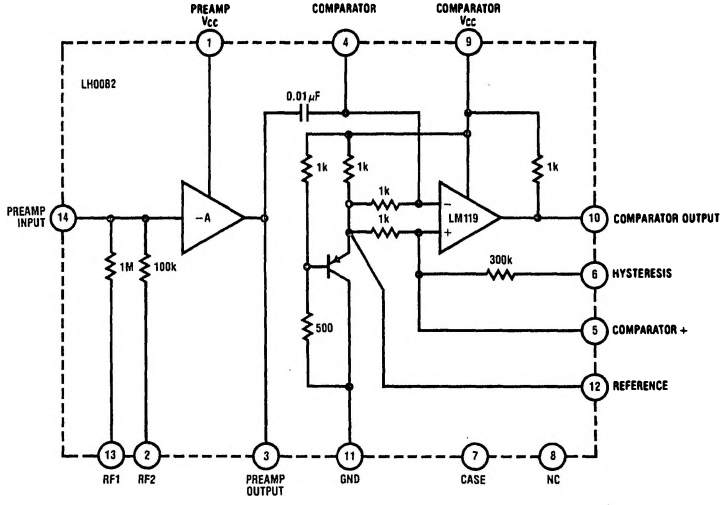
- Single 4.5V to 12V supply
- 600 MHz unity gain bandwidth
- Low noise
- Low edge jitter
- $<10^{-9}$ bit error rate
- Low input bias current
- Pin selectable sensitivity: −45 dBm/−35 dBm*
- CMOS/TTL compatibility
- Can be used with photodiodes, PIN photodiodes, phototransistors, avalanche photodiodes, and photomultipliers
- Hermetic dual-in-line metal package
- Highly versatile building block
- >21 dB dynamic range

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

*Assumes 0.5 A/W PIN diode input

Schematic Diagrams



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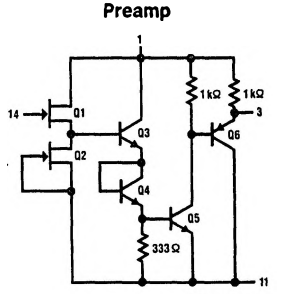

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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 1)

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 (Note 2) LH0082CD	−25°C to +85°C
Lead Temperature (Soldering, 10 sec.)	260°C
Input Current	±10 mA
ESD Susceptibility	TBD

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

Symbol	Parameter	Min	Typ	Max	Units
I_B	Input Bias Current		100	250	pA
C_{IN}	Input Capacitance			5	pF
A_V	Voltage Gain	50	90		V/V
$f_{3\,dB}$	−3 dB Frequency		18		MHz
V_O	Output Quiescent Voltage	1.9	2.1	2.6	V
$\Delta V_O/\Delta T$	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 = +5 V_{DC}, T_A = 25°C, see *Figure 2*

Symbol	Parameter	Min	Typ	Max	Units
R_{IN}	Comparator Input Resistance (to Reference)	0.90	1	1.10	kΩ
V_{HYST}	Hysteresis Voltage				
	Positive	7	8.7	11.4	mV
	Negative	5	6.9	8.8	mV
R_O	Output Pull-up Resistor	0.90	1	1.10	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} = 3.2 mA)		0.3	0.5	V
V_{OH}	(I_{OH} = −1 mA)	3.8	4		V
T_{PD}	(V_{IN} = 30 mV, V_{OD} = 15 mV)		160		ns
T_R	(C_L = 3 pF)		80		ns
T_F	(C_L = 3 pF)		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

Symbol	Parameter	Min	Typ	Max	Units
	High Sensitivity: R_F = 1 MΩ, (see *Figure 3*) Input Power for 10^{-9} BER (Bit Rate = 500 kbit NRZ)		200		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 kΩ, (see *Figure 4*) Input Power for 10^{-9} BER (Bit Rate = 2 Mbit NRZ)		800		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

Note 1: Refer to RETS0082D for LH0082D/883 and LH0082D-MIL specifications.

Note 2: For military temperature range, see RETS0082D.

DIGITAL EDGE JITTER

A potential problem in digital transmission systems is "edge jitter". Jitter is related to the system rise time and receiver noise and can be approximated by the following equation:

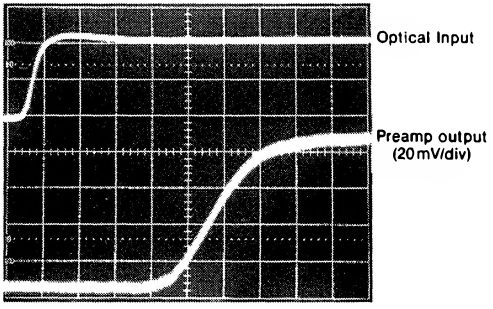
$$\text{RMS edge jitter} = \frac{\text{System rise time (10\%–90\%)}}{\text{(p/p signal voltage} \div \text{RMS noise voltage in receiver)}}$$

For a 5 Mbits/s NRZ operation using a 0.5 A/W PIN diode, the LH0082 requires a 2 μW peak optical power. This translates to 120 mV peak-to-peak signal voltage. Following through this equation the RMS edge jitter of the LH0082 is inconsequential at approximately 0.1 μs.

Fiber-Optic Receiver Preamp Response

R_F = 100 kΩ

Photodiode capacitance = 10 pF, V_{CC} = 5V



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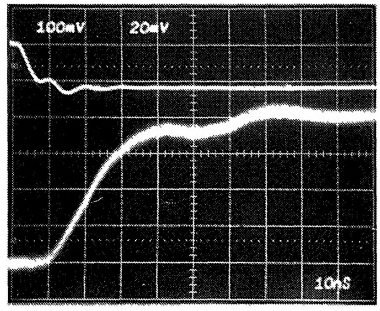
Preamp Voltage Mode Pulse Response



Input
(1 mV/div)

Output
(20 mV/div)

Small Signal

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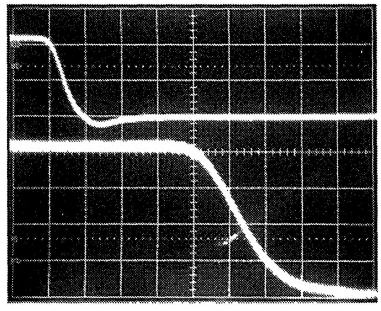

Optical Input

Preamp output
(20 mV/div)

Time (10 ns/div)

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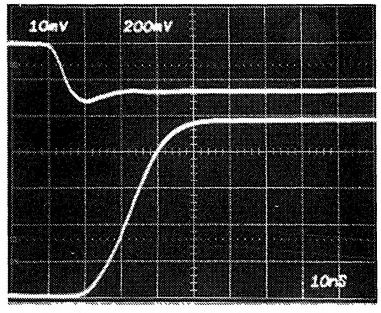

Input
(10 mV/div)

Output
(200 mV/div)

Large Signal

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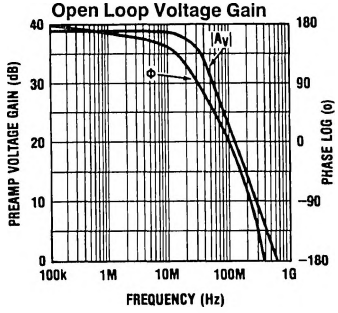
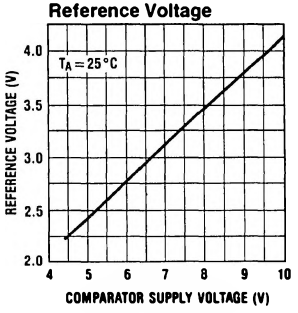
Typical Performance Characteristics

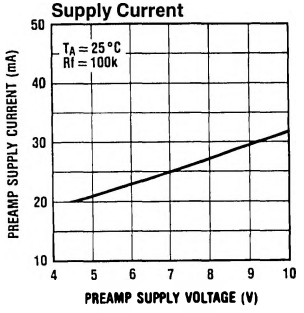
Open Loop Voltage Gain



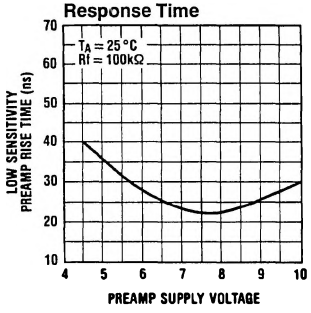
Reference Voltage



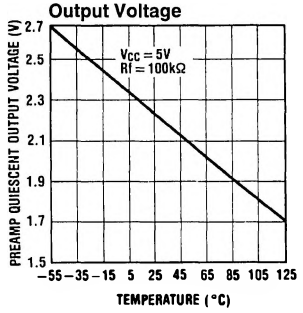
Supply Current



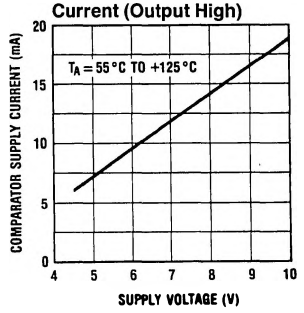
Response Time



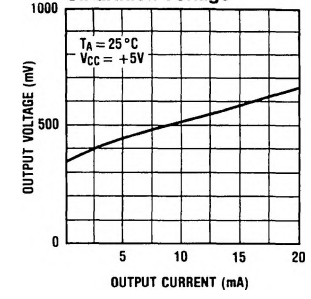
Output Voltage



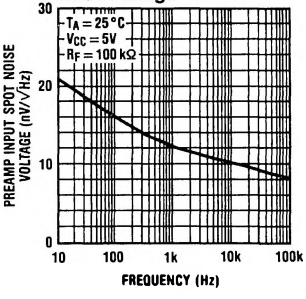
Comparator Supply Current (Output High)



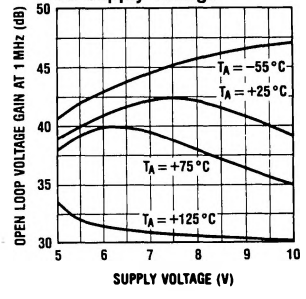
Comparator Output Saturation Voltage



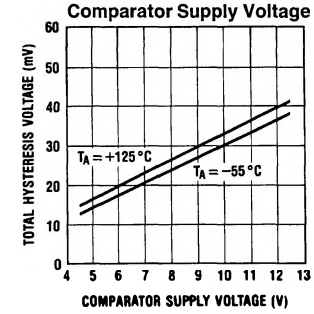
Preamp Input Spot Noise Voltage



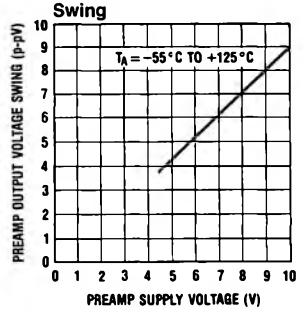
Preamp Open Loop Voltage vs. Supply Voltage



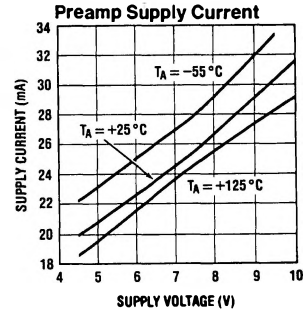
Hysteresis Voltage vs. Comparator Supply Voltage



Preamp Output Voltage Swing



Preamp Supply Current



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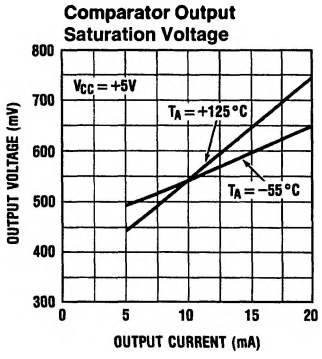
Typical Performance Characteristics (Continued)



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Applications Information

The gain-bandwidth of the LH0082 preamp is nearly 2 GHz, thus good bypassing of the supply voltage is necessary; a 3.3 μF tantalum capacitor in parallel with a 0.01 μF 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 5*.

For operations at higher data rates, *Figure 5* shows the use of an external comparator to enable speeds to 50 Mbit NRZ. *Figure 6, 7* and *8* 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 9*. Interfacing to a microcomputer-bus, (*Figure 10*), 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 56 kbits/s NRZ.

Analog data can be sent along a fiber-optic cable via digital means, (*Figure 11*). Low temperature drift can be obtained in the analog mode, by using the circuit shown in *Figure 12*.

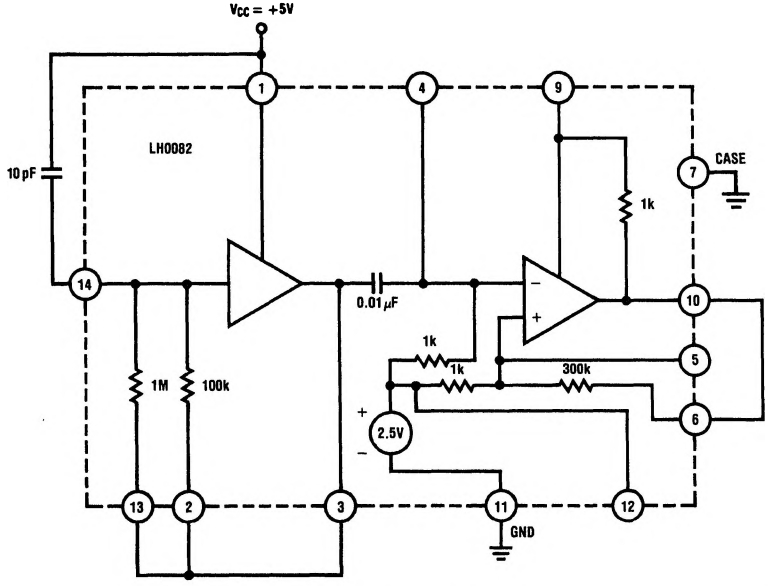

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FIGURE 1. Preamp Test Circuit

Applications Information (Continued)

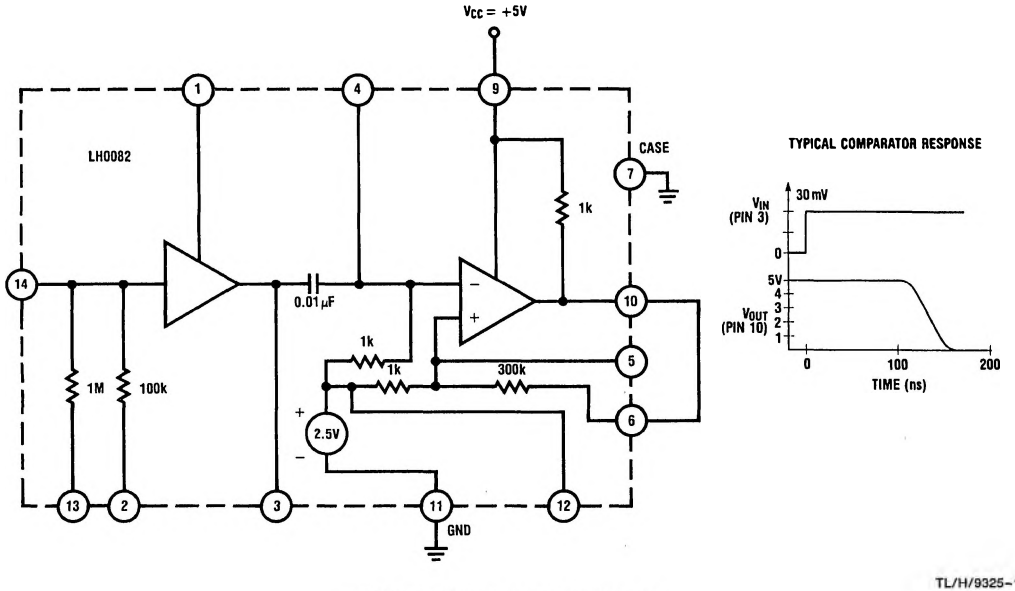

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FIGURE 2. Comparator Test Circuit

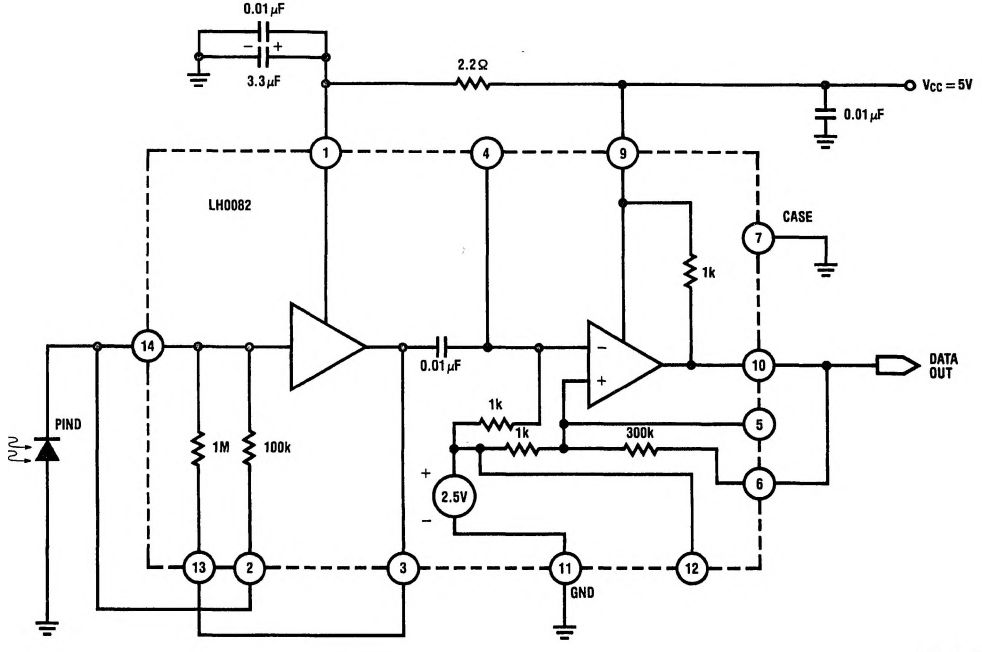

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FIGURE 3. Fiber-Optic Receiver, Basic High Sensitivity: 150 nW, 400 kbps NRZ

Applications Information (Continued)

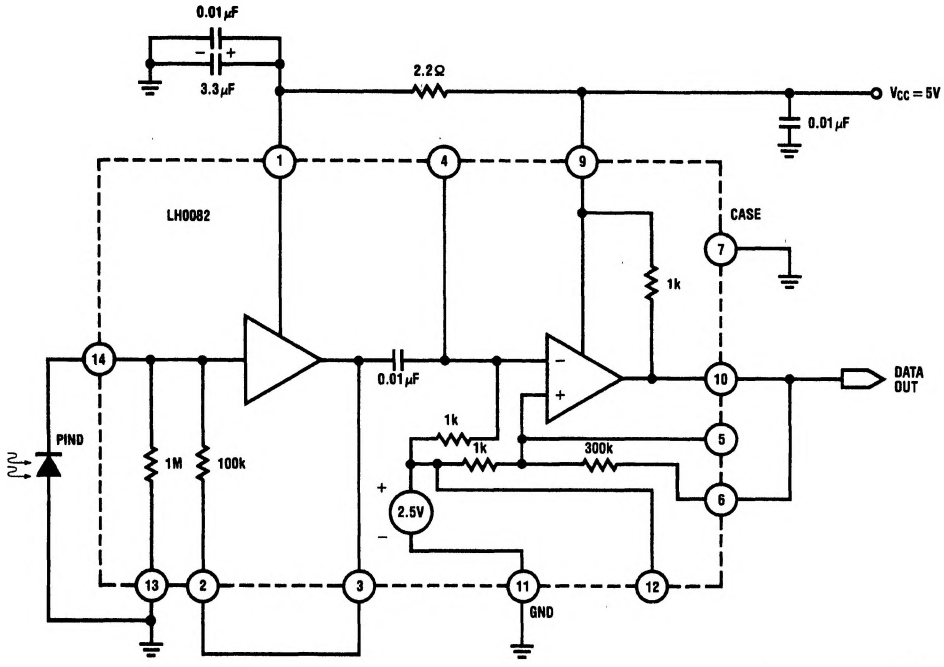

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FIGURE 4. Fiber-Optic Receiver, Basic Low Sensitivity: 2 μW, 5 Mbit, NRZ

Applications Information (Continued)

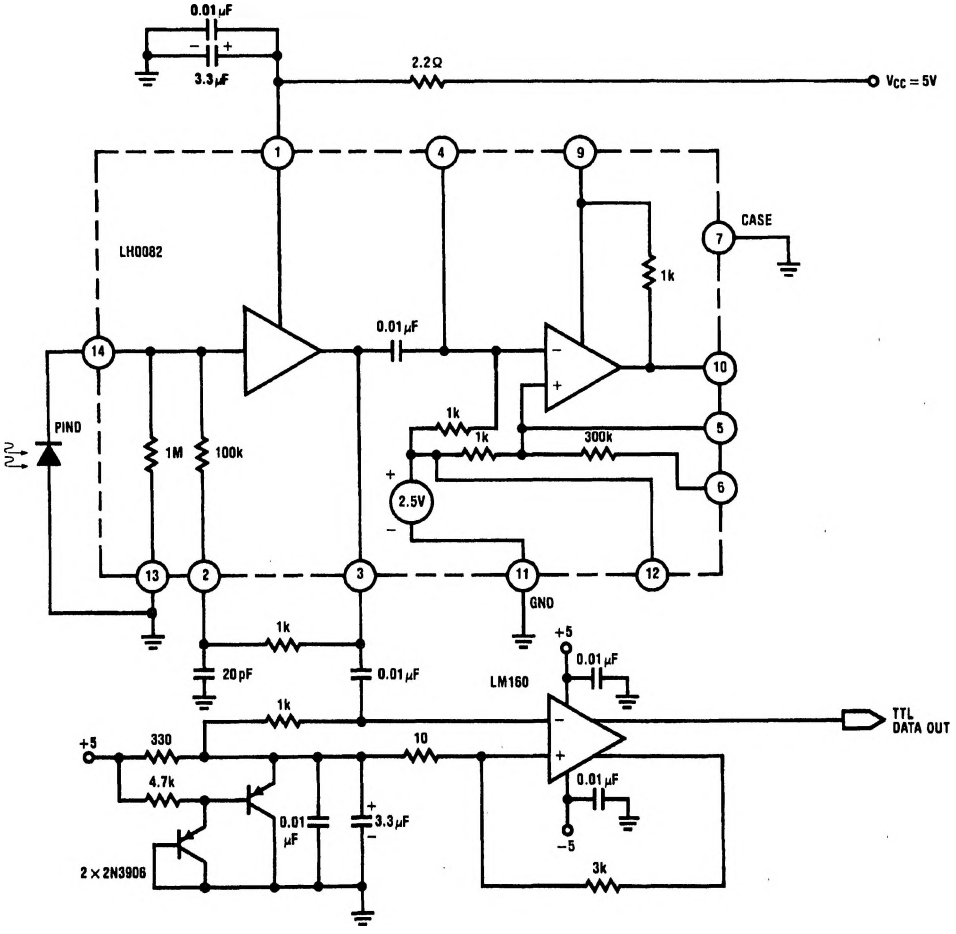

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FIGURE 5. High Speed—Low Sensitivity Receiver

Applications Information (Continued)

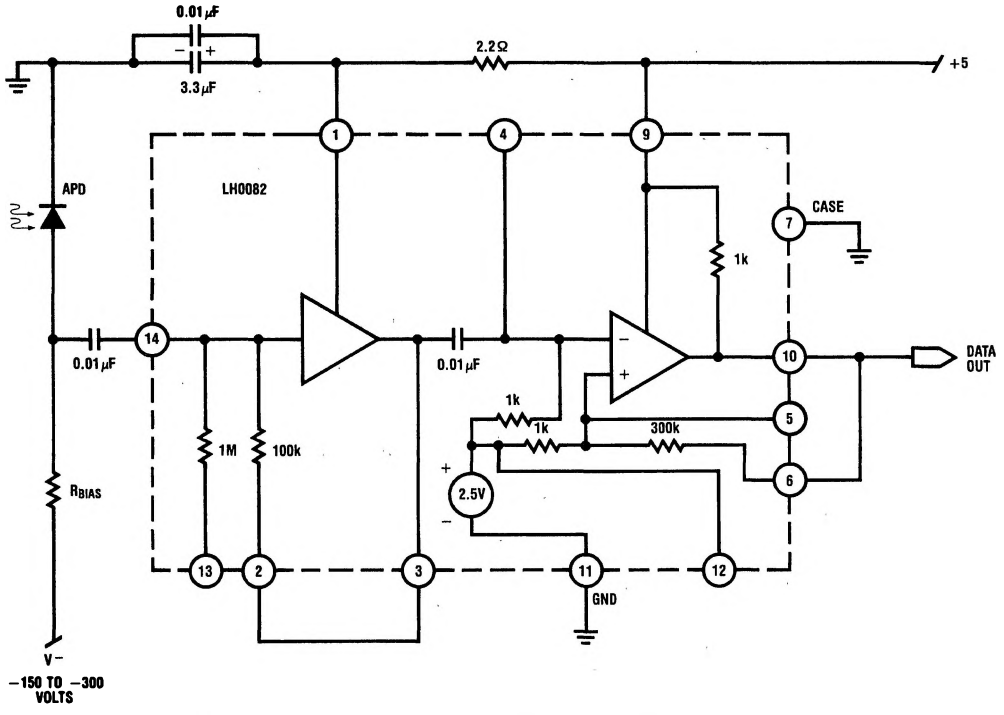

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FIGURE 6. Connection to Avalanche Photodiode

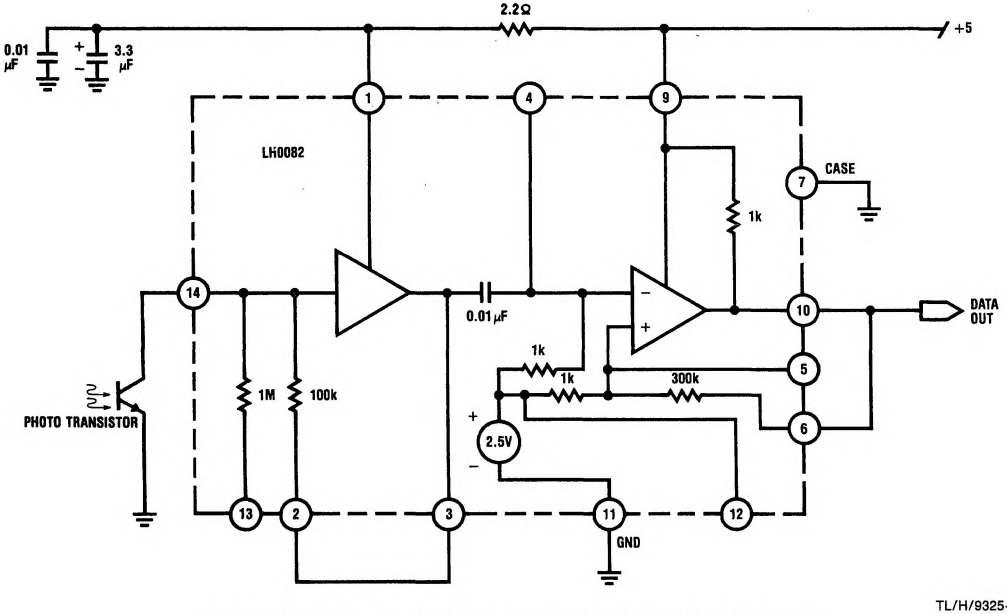

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FIGURE 7. Connection to Phototransistor—High Sensitivity, Low Speed

Applications Information (Continued)

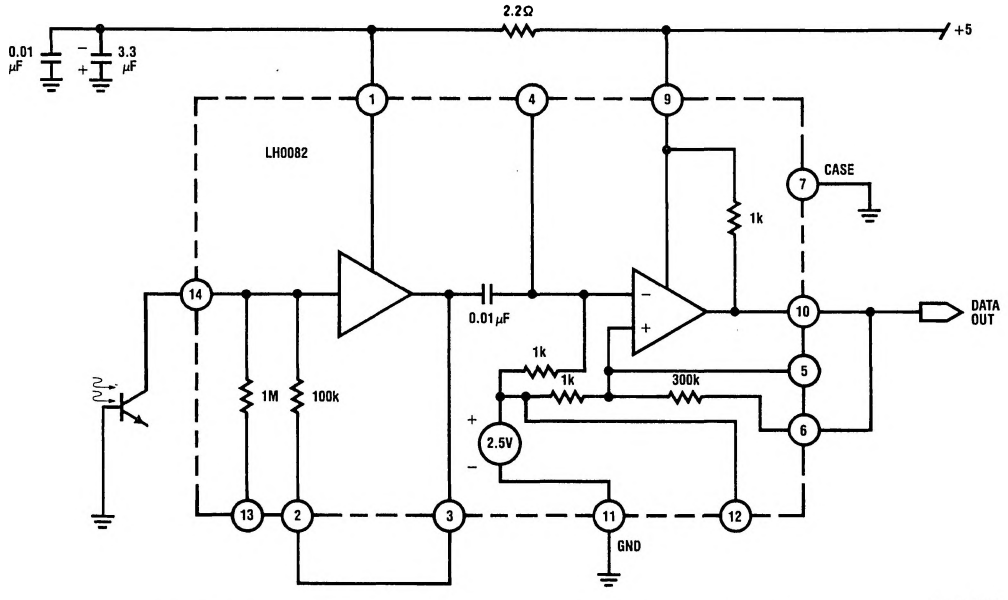

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FIGURE 8. Connection to Phototransistor—Low Sensitivity, High Speed Receiver

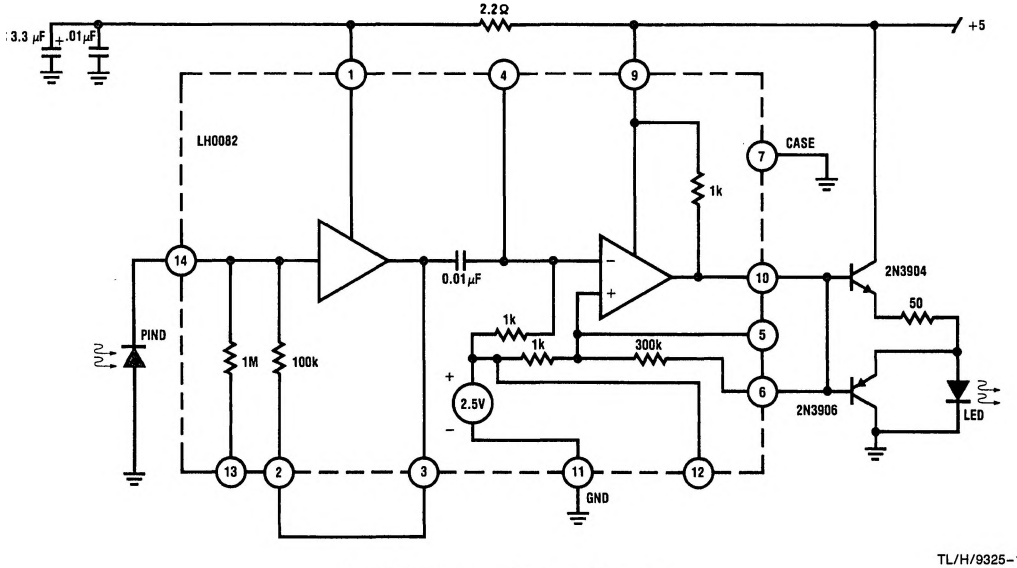

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FIGURE 9. Fiber-Optic Link Repeater

Applications Information (Continued)

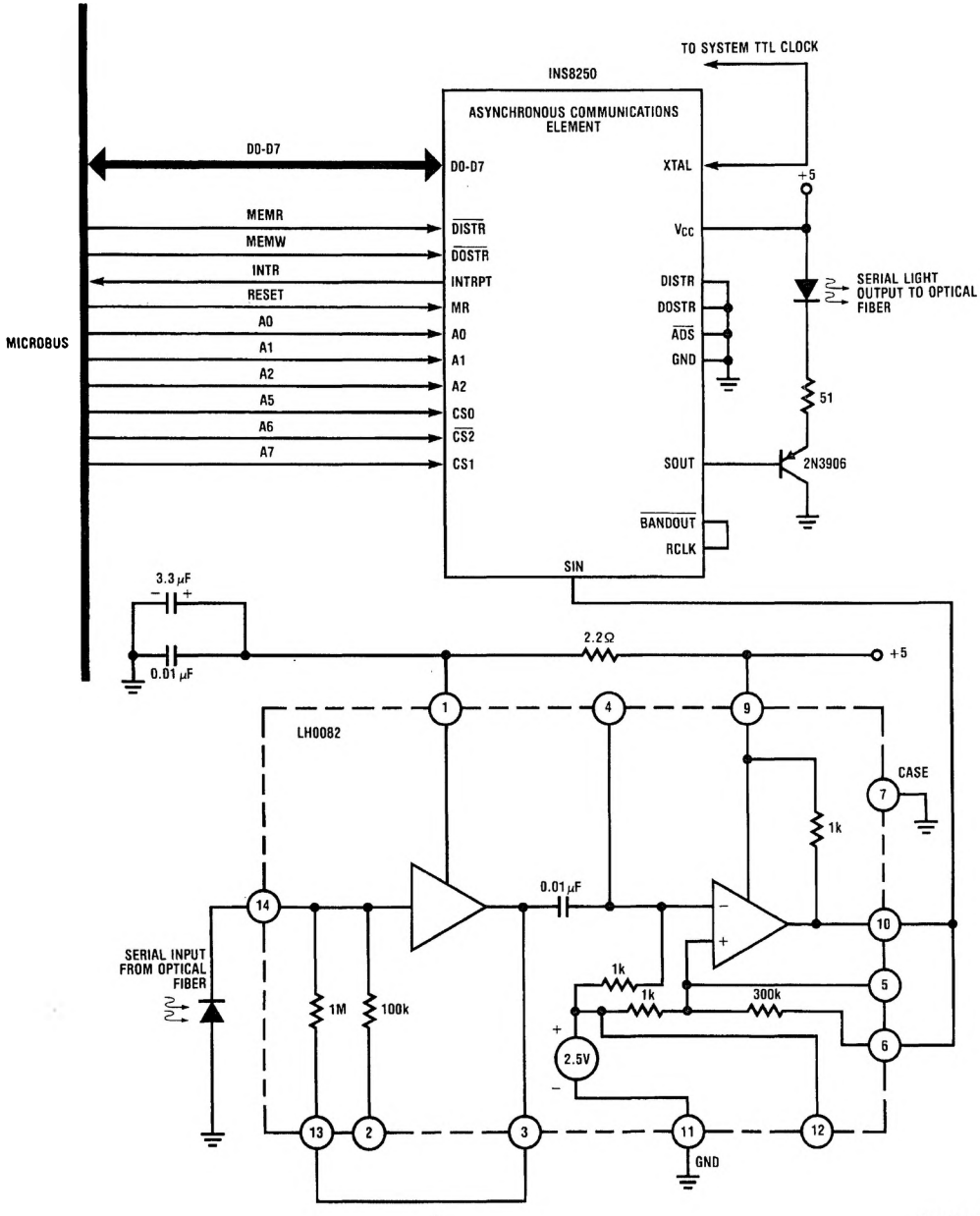

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FIGURE 10. Optical Link to Microbus

Applications Information (Continued)

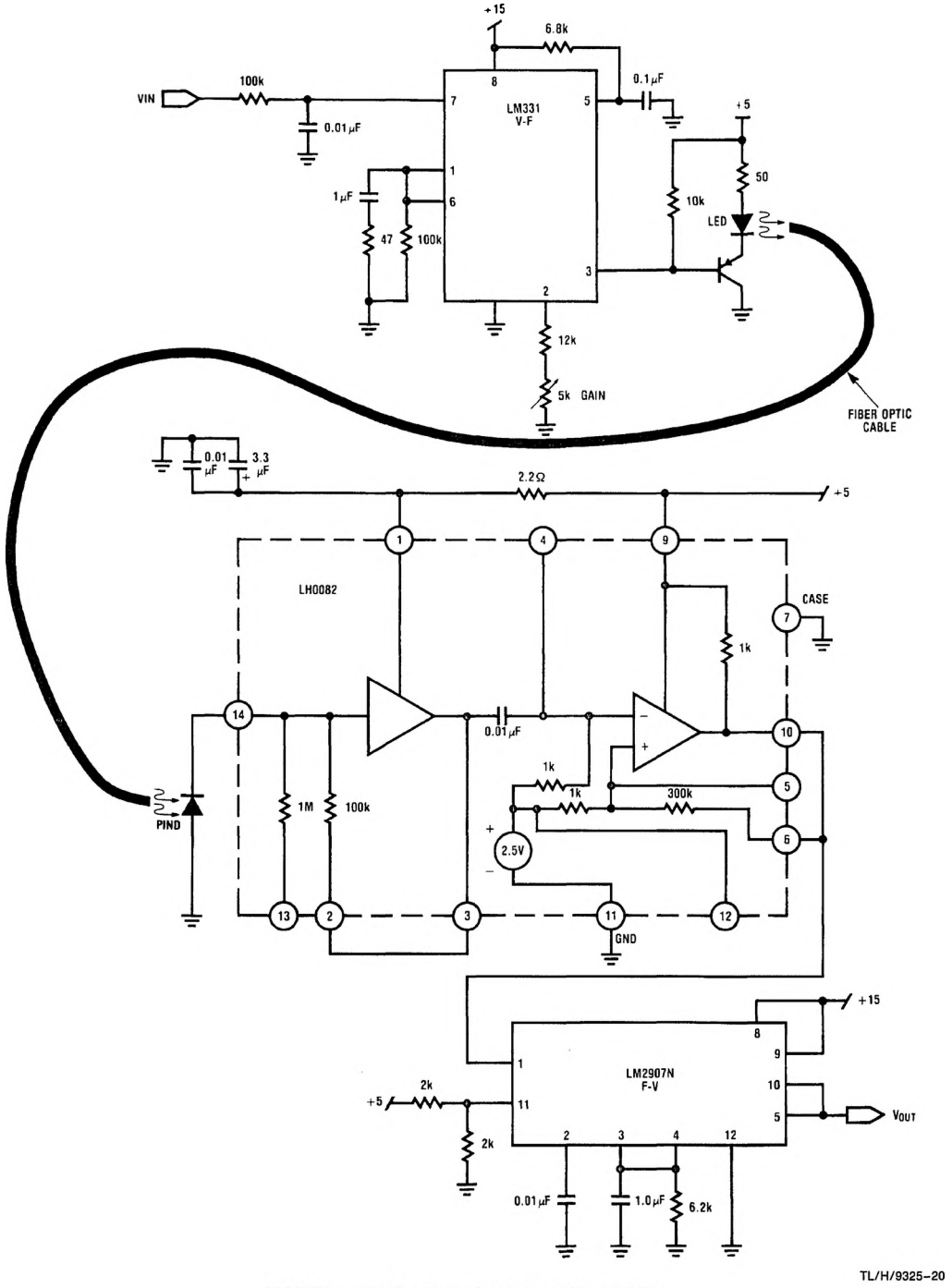

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FIGURE 11. Analog Data Link Using V/F and F/V

Applications Information (Continued)

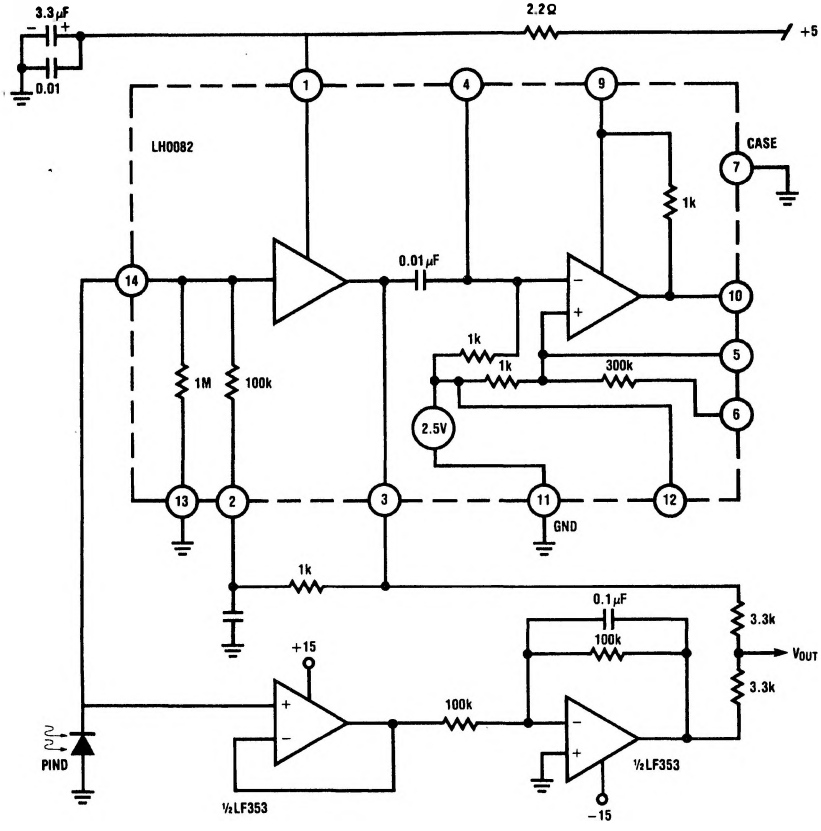

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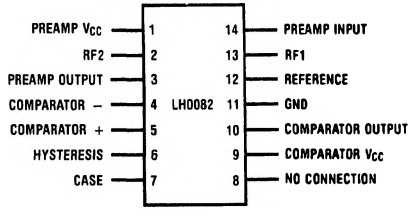
FIGURE 12. Low Temperature Drift Analog Receiver

Connection Diagram

Dual-In-Line Package



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Top View

Order Number LH0082CD
See NS Package Number D14F