National Semiconductor

DS36C278
Low Power Multipoint EIA-RS-485 Transceiver

General Description

The DS36C278 is a low power differential bus/line transceiver designed to meet the requirements of RS-485 standard for multipoint data transmission. In addition it is compatible with TIA/EIA-422-B.

The CMOS design offers significant power savings over its bipolar and ALS counterparts without sacrificing ruggedness against ESD damage. The device is ideal for use in battery powered or power conscious applications. I_{CC} is specified at 500 μA maximum.

The driver and receiver outputs feature TRI-STATE® capability. The driver outputs operate over the entire common mode range of −7V to +12V. Bus contention or fault situations that cause excessive power dissipation within the device are handled by a thermal shutdown circuit, which forces the driver outputs into the high impedance state.

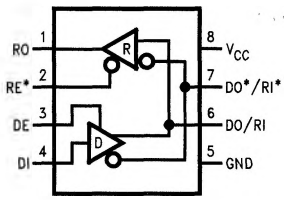
The receiver incorporates a fail safe circuit which guarantees a high output state when the inputs are left open.†

The DS36C278T is fully specified over the industrial temperature range (−40°C to +85°C).

Features

- 100% RS-485 compliant
  - — Guaranteed RS-485 device interoperation
- Low power CMOS design I_{CC} 500 μA max
- Built-in power up/down glitch-free circuitry
  - — Permits live transceiver insertion/displacement
- DIP and SOIC packages available
- Industrial temperature range −40°C to +85°C
- On-board thermal shutdown circuitry
  - — Prevents damage to the device in the event of excessive power dissipation
- Wide common mode range −7V to +12V
- Receiver open input fail-safe†
- ¼ unit load (DS36C278) ≥128 nodes
- ½ unit load (DS36C278T) ≥64 nodes
- ESD (human body model) ≥2 kV
- Drop in replacement for:
  - — LTC485, MAX485, DS75176, DS3695

Connection and Logic Diagram



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Order Number DS36C278TM, DS36C278TN, DS36C278M, DS36C278N
See NS Package Number M08A or N08E

Truth Table

DRIVER SECTION				
RE*	**DE**	**DI**	**DO/RI**	**DO*/RI***
X	H	H	H	L
X	H	L	L	H
X	L	X	Z	Z

RECEIVER SECTION			
RE*	**DE**	**RI-RI***	**RO**
L	L	≥ +0.2V	H
L	L	≤ −0.2V	L
H	L	X	Z
L	L	OPEN†	H

†**Note:** Non-terminated, open input only

Absolute Maximum Ratings (Note 1)

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

Supply Voltage (V_{CC})	+12V
Input Voltage (DE, RE*, & DI)	−0.5V to (V_{CC} +0.5V)
Common Mode (V_{CM})	
Driver Output/Receiver Input	±15V
Input Voltage (DO/RI, DO*/RI*)	±14V
Receiver Output Voltage	−0.5V to (V_{CC} +0.5V)
Maximum Package Power Dissipation @ +25°C	
M Package 1190 mW, derate	9.5 mW/°C above +25°C
N Package 744 mW, derate	6.0 mW/°C above +25°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering 4 sec)	+260°C

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{CC})	+4.75	+5.0	+5.25	V
Bus Voltage	−7		+12	V
Operating Free Air Temperature (Ta)				
DS36C278T	−40	25	+85	°C
DS36C278	0	25	+70	°C

Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (Notes 2 and 3)

Symbol	Parameter	Conditions	Reference		Min	Typ	Max	Units
DIFFERENTIAL DRIVER CHARACTERISTICS								
V_{OD1}	Differential Output Voltage	I_O = 0 mA (No Load)	(422) (485)		1.5		5.0	V
V_{OD0}	Output Voltage	I_O = 0 mA			0		5.0	V
V_{OD0*}	Output Voltage	(Output to GND)			0		5.0	V
V_{OD2}	Differential Output Voltage (Termination Load)	R_L = 50Ω	(422)	*Figure 1*	2.0	2.8		V
		R_L = 27Ω	(485)		1.5	2.3	5.0	V
ΔV_{OD2}	Balance of V_{OD2} $\lvert V_{OD2} - V_{OD2*}\rvert$	R_L = 27Ω or 50Ω	(Note 4) (422, 485)		−0.2	0.1	+0.2	V
V_{OD3}	Differential Output Voltage (Full Load)	R1 = 54Ω, R2 = 375Ω V_{TEST} = −7V to +12V	*Figure 2*		1.5	2.0	5.0	V
V_{OC}	Driver Common Mode Output Voltage	R_L = 27Ω	(485)	*Figure 1*	0		3.0	V
		R_L = 50Ω	(422)		0		3.0	V
ΔV_{OC}	Balance of V_{OC} $\lvert V_{OC} - V_{OC*}\rvert$	R_L = 27Ω or R_L = 50Ω	(Note 4) (422, 485)		−0.2		+0.2	V
I_{OSD}	Driver Output Short-Circuit Current	V_O = +12V	(485) *Figure 4*			200	+250	mA
		V_O = −7V	(485)			−190	−250	mA
RECEIVER CHARACTERISTICS								
V_{TH}	Differential Input High Threshold Voltage	V_O = V_{OH}, I_O = −0.4V −7V ≤ V_{CM} ≤ +12V	(Note 5) (422, 485)			+0.035	+0.2	V
V_{TL}	Differential Input Low Threshold Voltage	V_O = V_{OL}, I_O = 0.4 mA −7V ≤ V_{CM} ≤ +12V			−0.2	−0.035		V
V_{HST}	Hysteresis	V_{CM} = 0V	(Note 6)			70		mV
R_{IN}	Input Resistance	−7V ≤ V_{CM} ≤ +12V	DS36C278T		24	68		kΩ
R_{IN}	Input Resistance	−7V ≤ V_{CM} ≤ +12V	DS36C278		48	68		kΩ

Electrical Characteristics (Continued)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (Notes 2 and 3)

Symbol	Parameter	Conditions		Reference	Min	Typ	Max	Units
I_{IN}	Line Input Current (Note 7)	Other Input = 0V, DE = V_{IL}, RE* = V_{IL}, V_{CC} = 4.75 to 5.25 or 0V	DS36C278	V_{IN} = +12V	0	0.19	0.25	mA
				V_{IN} = −7V	0	−0.1	−0.2	mA
			DS36C278T	V_{IN} = +12V	0	0.19	0.5	mA
				V_{IN} = −7V	0	−0.1	−0.4	mA
I_{ING}	Line Input Current Glitch (Note 7)	Other Input = 0V, DE = V_{IL}, RE* = V_{IL}, V_{CC} = +3.0V or 0V, T_A = 25°C	DS36C278	V_{IN} = +12V	0	0.19	0.25	mA
				V_{IN} = −7V	0	−0.1	−0.2	mA
			DS36C278T	V_{IN} = +12V	0	0.19	0.5	mA
				V_{IN} = −7V	0	−0.1	−0.4	mA
I_B	Input Balance Test	RS = 500Ω		(422) (Note 9)			±400	mV
V_{OH}	High Level Output Voltage	I_{OH} = −4 mA, V_{ID} = +0.2V		RO *Figure 11*	3.5	4.6		V
V_{OL}	Low Level Output Voltage	I_{OL} = +4 mA, V_{ID} = −0.2V				0.3	0.5	V
I_{OSR}	Short Circuit Current	V_O = GND		RO	7	35	85	mA
I_{OZR}	TRI-STATE Leakage Current	V_O = 0.4V to 2.4V					±1	μA
DEVICE CHARACTERISTICS								
V_{IH}	High Level Input Voltage			DE, RE*, DI	2.0		V_{CC}	V
V_{IL}	Low Level Input Voltage				GND		0.8	V
I_{IH}	High Level Input Current	V_{IH} = V_{CC}					2	μA
I_{IL}	Low Level Input Current	V_{CC} = 5V	V_{IL} = 0V				−2	μA
		V_{CC} = +3.0V					−2	μA
I_{CC}	Power Supply Current (No Load)	Driver and Receiver ON		V_{CC}		200	500	μA
I_{CCR}		Driver OFF, Receiver ON				200	500	μA
I_{CCD}		Driver ON, Receiver OFF				200	500	μA
I_{CCZ}		Driver and Receiver OFF				200	500	μA

Switching Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (Notes 3 and 8)

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
DRIVER CHARACTERISTICS							
t_{PHLD}	Differential Propagation Delay High to Low	R_L = 54Ω, C_L = 100 pF	*Figures 5, 6*	10	39	80	ns
t_{PLHD}	Differential Propagation Delay Low to High			10	40	80	ns
t_{SKD}	Differential Skew $\lvert t_{PHLD} - t_{PLHD} \rvert$			0	1	10	ns
t_r	Rise Time			3	25	50	ns
t_f	Fall Time			3	25	50	ns
t_{PHZ}	Disable Time High to Z	C_L = 15 pF	*Figures 7, 8*	—	80	200	ns
t_{PLZ}	Disable Time Low to Z	RE * = L	*Figures 9, 10*	—	80	200	ns
t_{PZH}	Enable Time Z to High	C_L = 100 pF	*Figures 7, 8*	—	50	200	ns
t_{PZL}	Enable Time Z to Low	RE * = L	*Figures 9, 10*	—	65	200	ns

Switching Characteristics (Continued)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (Notes 3 and 8)

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
RECEIVER CHARACTERISTICS							
t_{PHL}	Propagation Delay High to Low	C_L = 15 pF	*Figures 12, 13*	30	210	400	ns
t_{PLH}	Propagation Delay Low to High			30	190	400	ns
t_{SK}	Skew, $\|t_{PHL} - t_{PLH}\|$			0	20	50	ns
t_{PLZ}	Output Disable Time	C_L = 15 pF	*Figures 14, 15, 16*	—	50	150	ns
t_{PHZ}				—	55	150	ns
t_{PZL}	Output Enable Time			—	40	150	ns
t_{PZH}				—	45	150	ns

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

Note 2: Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except V_{OD1} and V_{OD2}.

Note 3: All typicals are given for: V_{CC} = +5.0V, T_A = + 25°C.

Note 4: Delta $|V_{OD2}|$ and Delta $|V_{OC}|$ are changes in magnitude of V_{OD2} and V_{OC}, respectively, that occur when input changes state.

Note 5: Threshold parameter limits specified as an algebraic value rather than by magnitude.

Note 6: Hysteresis defined as $V_{HST} = V_{TH} - V_{TL}$.

Note 7: I_{IN} includes the receiver input current and driver TRI-STATE leakage current.

Note 8: C_L includes probe and jig capacitance.

Note 9: For complete details of test, see RS-485.

Parameter Measurement Information

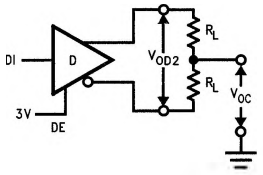

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FIGURE 1. Driver V_{OD2} and V_{OC}

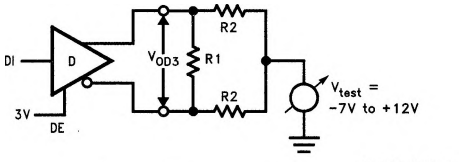

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FIGURE 2. Driver V_{OD3}

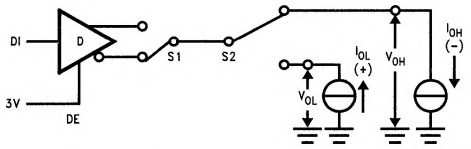

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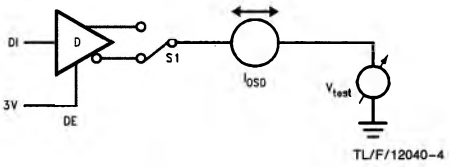
FIGURE 3. Driver V_{OH} and V_{OL}



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Vtest = −7V to +12V

FIGURE 4. Driver I_{OSD}

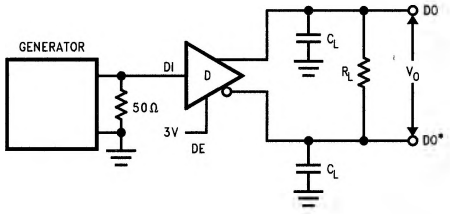

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FIGURE 5. Driver Differential Propagation Delay Test Circuit

Parameter Measurement Information (Continued)

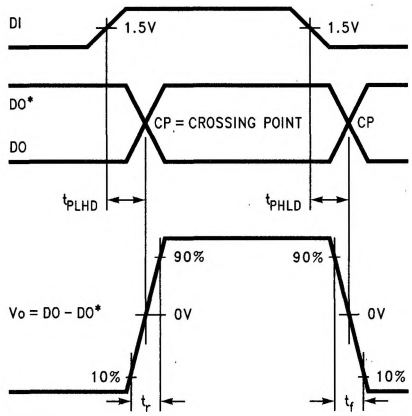

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FIGURE 6. Driver Differential Propagation Delays and Differential Rise and Fall Times

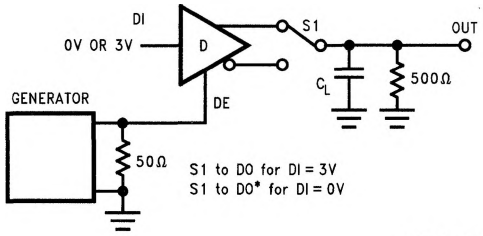

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FIGURE 7. TRI-STATE Test Circuit (t_{PZH}, t_{PHZ})

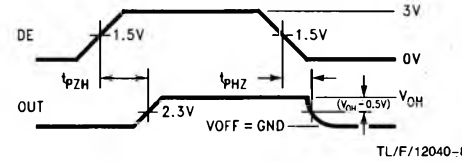

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FIGURE 8. TRI-STATE Waveforms (t_{PZH}, t_{PHZ})

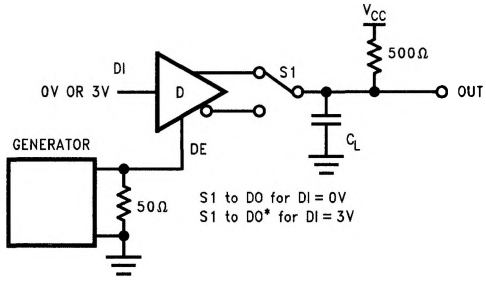

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FIGURE 9. TRI-STATE Test Circuit (t_{PZL}, t_{PLZ})

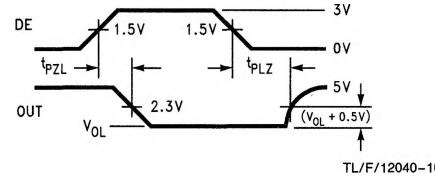

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FIGURE 10. TRI-STATE Waveforms (t_{PZL}, t_{PLZ})

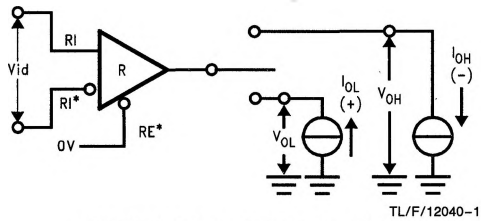

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FIGURE 11. Receiver V_{OH} and V_{OL}

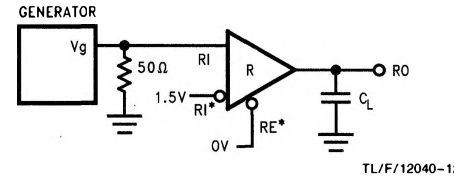

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FIGURE 12. Receiver Differential Propagation Delay Test Circuit

Parameter Measurement Information (Continued)

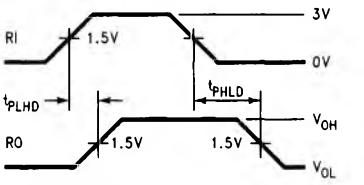

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FIGURE 13. Receiver Differential Propagation Delay Waveforms

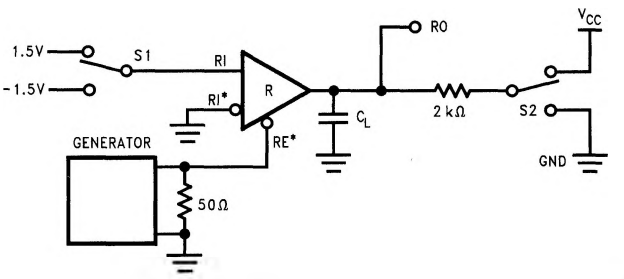

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FIGURE 14. Receiver TRI-STATE Test Circuit

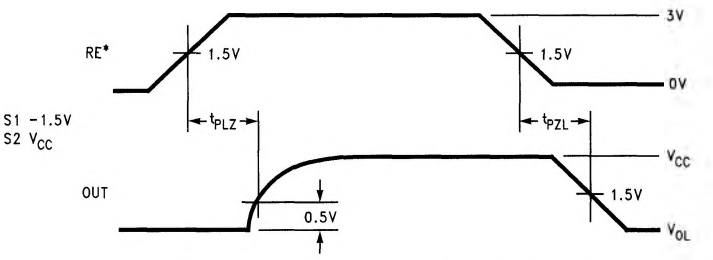

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FIGURE 15. Receiver Enable and Disable Waveforms (t_{PLZ}, t_{PZL})

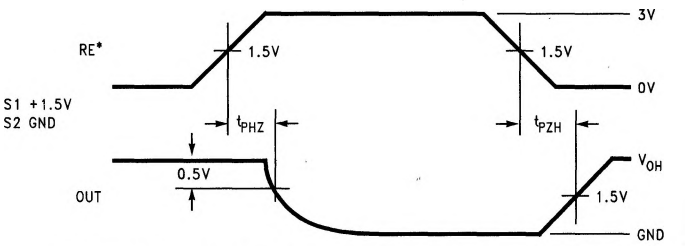

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FIGURE 16. Receiver Enable and Disable Waveforms (t_{PHZ}, t_{PZH})

Typical Application Information

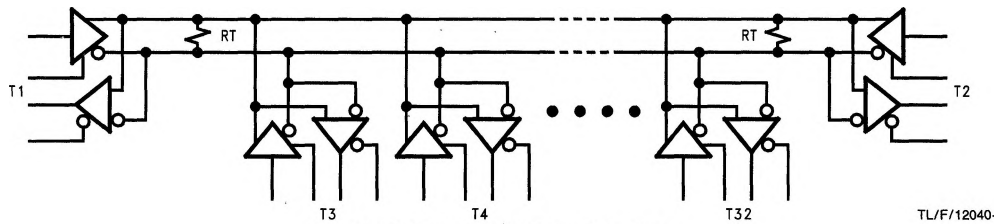

FIGURE 17. Typical RS-485 Bus Interface

TABLE I. Device Pin Descriptions

Pin No.	Name	Description
1	RO	Receiver Output: When RE (Receiver Enable) is LOW, the receiver is enabled (ON), if DO/RI ≥ DO*/RI* by 200 mV, RO will be HIGH. If DO/RI ≤ DO*/RI* by 200 mV, RO will be LOW. Additionally RO will be HIGH for OPEN (Non-terminated) Inputs.
2	RE*	Receiver Output Enable: When RE* is LOW the receiver output is enabled. When RE* is HIGH, the receiver output is in TRI-STATE (OFF).
3	DE	Driver Output Enable: When DE is HIGH, the driver outputs are enabled. When DE is LOW, the driver outputs are in TRI-STATE (OFF).
4	DI	Driver Input: When DE (Driver Enable) is HIGH, the driver is enabled, if DI is LOW, then DO/RI will be LOW and DO*/RI* will be HIGH. If DI is HIGH, then DO/RI is HIGH and DO*/RI* is LOW.
5	GND	Ground Connection.
6	DO/RI	Driver Output/Receiver Input, 485 Bus Pin.
7	DO*/RI*	Driver Output/Receiver Input, 485 Bus Pin.
8	V_{CC}	Positive Power Supply Connection: Recommended operating range for V_{CC} is +4.75V to +5.25V.

Unit Load

A unit load for an RS-485 receiver is defined by the input current versus the input voltage curve. The gray shaded region is the defined operating range from −7V to +12V. The top border extending from −3V at 0 mA to +12V at +1 mA is defined as one unit load. Likewise, the bottom border extending from +5V at 0 mA to −7V at −0.8 mA is also defined as one unit load (see *Figure 18*). An RS-485 driver is capable of driving up to 32 unit loads. This allows up to 32 nodes on a single bus. Although sufficient for many applications, it is sometimes desirable to have even more nodes. For example, an aircraft that has 32 rows with 4 seats per row would benefit from having 128 nodes on one bus. This would allow signals to be transferred to and from each individual seat to 1 main station. Usually there is one or two less seats in the last row of the aircraft near the restrooms and food storage area. This frees the node for the main station.

The DS36C278, the DS36C279, and the DS36C280 all have ½ unit load and ¼ unit load (UL) options available. These devices will allow up to 64 nodes or 128 nodes guaranteed over temperature depending upon which option is selected. The ½ UL option is available in industrial temperature and the ¼ UL is available in commercial temperature.

First, for a ½ UL device the top and bottom borders shown in *Figure 18* are scaled. Both 0 mA reference points at +5V and −3V stay the same. The other reference points are +12V at +0.5 mA for the top border and −7V at −0.4 mA for the bottom border (see *Figure 18*). Second, for a ¼ UL device the top and bottom borders shown in *Figure 18* are scaled also. Again, both 0 mA reference points at +5V and −3V stay the same. The other reference points are +12V at +0.25 mA for the top border and −7V at −0.2 mA for the bottom border (see *Figure 18*).

The advantage of the ½ UL and ¼ UL devices is the increased number of nodes on one bus. In a single master multi-slave type of application where the number of slaves exceeds 32, the DS36C278/279/280 may save in the cost of extra devices like repeaters, extra media like cable, and/or extra components like resistors.

The DS36C279 and DS36C280 have an additional feature which offers more advantages. The DS36C279 has an automatic sleep mode function for power conscious applications. The DS36C280 has a slew rate control for EMI conscious applications. Refer to the sleep mode and slew rate control portion of the application information section in the corresponding datasheet for more information on these features.

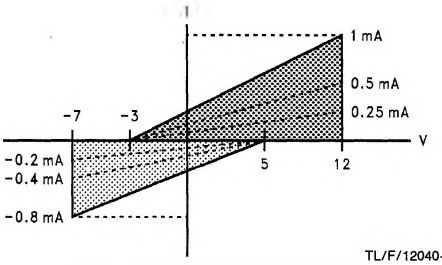

FIGURE 18. Input Current vs Input Voltage Operating Range