

Dual Low Power Operational Amplifiers

Utilizing the circuit designs perfected for recently introduced Quad Operational Amplifiers, these dual operational amplifiers feature 1) low power drain, 2) a common mode input voltage range extending to ground/V_{EE}, 3) single supply or split supply operation and 4) pinouts compatible with the popular MC1558 dual operational amplifier. The LM158 series is equivalent to one–half of an LM124.

These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 32 V, with quiescent currents about one–fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Single and Split Supply Operation
- Similar Performance to the Popular MC1558
- ESD Clamps on the Inputs Increase Ruggedness of the Device without Affecting Operation

MAXIMUM RATINGS ($T_A = +25^{\circ}C$, unless otherwise noted.)

Rating	Symbol	LM258 LM358	LM2904 LM2904V	Unit		
Power Supply Voltages Single Supply Split Supplies	V _{CC} , V _{EE}	32 ±16	26 ±13	Vdc		
Input Differential Voltage Range (Note 1)	VIDR	±32	±26	Vdc		
Input Common Mode Voltage Range (Note 2)	VICR	-0.3 to 32	-0.3 to 26	Vdc		
Output Short Circuit Duration	tsc	Conti	nuous			
Junction Temperature	TJ	1	50	°C		
Storage Temperature Range	T _{stg}	-55 to +125		-55 to +125		°C
Operating Ambient Temperature Range	TA			°C		
LM258		-25 to +85	_			
LM358		0 to +70	_			
LM2904 LM2904V		_ _	-40 to +105 -40 to +125			

NOTES: 1. Split Power Supplies.

2. For Supply Voltages less than 32 V for the LM258/358 and 26 V for the LM2904, the absolute maximum input voltage is equal to the supply voltage.

LM358, LM258, LM2904, LM2904V

DUAL DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

SEMICONDUCTOR TECHNICAL DATA

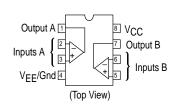


N SUFFIX PLASTIC PACKAGE CASE 626



D SUFFIXPLASTIC PACKAGE
CASE 751
(SO-8)

PIN CONNECTIONS



ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM2904D	$T_A = -40^{\circ} \text{ to } +105^{\circ}\text{C}$	SO-8
LM2904N	1A = 40 10 1 100 0	Plastic DIP
LM2904VD	$T_A = -40^{\circ} \text{ to } +125^{\circ}\text{C}$	SO-8
LM2904VN	1A = 40 10 1125 0	Plastic DIP
LM258D	$T_A = -25^{\circ} \text{ to } +85^{\circ}\text{C}$	SO-8
LM258N	1A = 20 to 100 0	Plastic DIP
LM358D	T _A = 0° to +70°C	SO-8
LM358N	1A = 0 10 +70 C	Plastic DIP

ELECTRICAL CHARACTERISTICS ($V_{CC} = 5.0 \text{ V}$, $V_{EE} = \text{Gnd}$, $T_A = 25^{\circ}\text{C}$, unless otherwise noted.)

				$\frac{1, 1_A = 25^{\circ}\text{C, unless otr}}{\text{LM358}}$		LM2904			LM2904V				
Symbol	Min	Тур	Max	Min	Тур	Max	Min	Тур	Max	Min	Тур	Max	Unit
VIO	- - -	2.0	5.0 7.0 2.0	-	2.0	7.0 9.0	-	2.0	7.0 10	-	-	- 13	mV
ΔV _{IO} /ΔΤ	-	7.0	-	-	7.0	-	_	7.0	-	-	7.0	-	μV/°C
I _{IO}	- - - -	3.0 - -45 -50	30 100 –150 –300	- - -	5.0 - -45 -50	50 150 –250 –500	- - - -	5.0 45 –45 –50	50 200 –250 –500	- - -	5.0 45 –45 –50	50 200 –250 –500	nA
ΔΙ _{ΙΟ} /ΔΤ	_	10	-	_	10	_	_	10	-	_	10	_	pA/°C
VICR	0 0	- -	28.3 28	0 0	1 1	28.3 28	0 0	- -	24.3 24	0 0	- -	24.3 24	>
V _{IDR}	-	-	VCC	-	-	VCC	-	-	VCC	-	-	VCC	V
AVOL	50 25	100	-	25 15	100	-	25 15	100	-	25 15	100	-	V/mV
CS	-	-120	-	-	-120	-	-	-120	-	-	-120	_	dB
CMR	70	85	_	65	70	_	50	70	-	50	70	_	dB
PSR	65	100	-	65	100	_	50	100	-	50	100	_	dB
Voн	3.3 26 27	3.5 - 28		3.3 26 27	3.5 - 28		3.3 22 23	3.5 - 24		3.3 22 23	3.5 - 24		V
VOL	-	5.0	20	-	5.0	20	-	5.0	20	-	5.0	20	mV
I _O +	20	40	-	20	40	-	20	40	-	20	40	_	mA
lO-	10 12	20 50	- -	10 12	20 50	- -	10 –	20 -	-	10 -	20 -	- -	mA μA
Isc	-	40	60	_	40	60	_	40	60	-	40	60	mA
lcc	-	1.5	3.0	-	1.5 0.7	3.0	-	1.5	3.0	-	1.5	3.0	mA
	Symbol VIO AVIO/AT IIO IIB AIIO/AT VICR VIDR AVOL CS CMR PSR VOH IO+ IO- ISC	Symbol Min	Symbol Min Typ VIO - 2.0 - - - - - - ΔVIO/ΔT - 7.0 IIO - - IIB - - - - - VICR 0 - O - - VIDR - - - - - VIDR - - CS - - CMR 70 85 PSR 65 100 VOH 3.3 3.5 26 - - 27 28 VOL - 5.0 IO + 20 40 IO - 10 20 1SC - 40 ICC - 1.5	Symbol Min Typ Max VIO - 2.0 5.0 - - - 7.0 - - - 2.0 ΔVIO/ΔT - 7.0 - IIO - 3.0 30 IIB - -45 -150 - - -50 -300 ΔIIO/ΔT - 10 - VICR 0 - 28.3 VIDR - - VCC AVOL 50 100 - 25 - - - CS - -120 - PSR 65 100 - VOH 3.3 3.5 - 26 - - - VOL - 5.0 20 IO + 20 40 - IO - 10 20 - 10 - <t< td=""><td>Symbol LM258 Min Typ Max Min VIO - 2.0 5.0 - - - - 7.0 - - - - 7.0 - IIO - 3.0 30 - - - - 100 - - - - - - IIB - - - - - - - - - - - - VICR 0 - 28.3 0 - - - VIDR - - VCC - - - - - VIDR -</td><td>Symbol Min Typ Max Min Typ VIO - 2.0 5.0 - 2.0 - 2.0 5.0 - 2.0 - - 2.0 - - - - 2.0 - - - - - - - - - - - - IIO - - - - IIB - -45 -150 - -45 - - -50 -300 - -50 ΔIIO/ΔΤ - 10 - - -50 ΔIIO/ΔΤ - 10 - - -50 VICR 0 - 28.3 0 - VIDR - - VCC - - - - - - - - - - - -</td></t<> <td>Symbol Min Typ Max Min Typ Max VIO - 2.0 5.0 - 2.0 7.0 - - 2.0 5.0 - 2.0 7.0 - - - 7.0 - - 9.0 ΔVΙΟ/ΔΤ - 7.0 - - 9.0 IIO - 3.0 30 - 5.0 50 IIB - - - 150 -<td>Symbol LM258 LM358 Max Min Typ Max Min VIO Min Typ Max Min Typ Max Min VIO - 2.0 5.0 - 2.0 7.0 - AVIO/ΔT - 7.0 - - 9.0 - IIO - 3.0 30 - - 0.0 - IIB - -45 -150 - -45 -250 - IIB - -45 -150 - -45 -250 - VICR 0 - 28.3 0 - 28.3 0 VIDR - - VCC - - VCC - AVOL 50 100 - 25 100 - 25 CS - -120 - - -</td><td>Symbol LM258 LM2904 VIO Min Typ Max Min Typ Max Min Typ VIO - 2.0 5.0 - 2.0 7.0 - 2.0 - - - 7.0 - - 9.0 - - - - - 7.0 - - 9.0 - - ΔVIO/ΔΤ - 3.0 30 - 5.0 50 - 5.0 IIB - -45 -150 - -45 -250 - - -50 ΔIΙΟ/ΔΤ - 10 - - - -50 -500 - - -50 ΔΙΙΟ/ΔΤ - 10 -<!--</td--><td>Symbol Min Typ Max - 2.0 5.0 - 2.0 7.0 - 2.0 7.0 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 250 - 45 200 - 28 20 - 250 - 45 220 - 25 - 45 220 - 25 - 45 220 - 25 20 - 28.3 0 -</td><td> Symbol Min Typ Max Min Typ Max Min Typ Max Min Min </td><td>Symbol Min Typ Max Min Typ Min Typ Max Min Typ Min Min Typ Min Min Typ Min Typ Min Typ Min Typ Min Typ</td><td>Symbol Min Typ Max Min July Min Typ Max Min July Max Min Typ Max M</td></td></td>	Symbol LM258 Min Typ Max Min VIO - 2.0 5.0 - - - - 7.0 - - - - 7.0 - IIO - 3.0 30 - - - - 100 - - - - - - IIB - - - - - - - - - - - - VICR 0 - 28.3 0 - - - VIDR - - VCC - - - - - VIDR -	Symbol Min Typ Max Min Typ VIO - 2.0 5.0 - 2.0 - 2.0 5.0 - 2.0 - - 2.0 - - - - 2.0 - - - - - - - - - - - - IIO - - - - IIB - -45 -150 - -45 - - -50 -300 - -50 ΔIIO/ΔΤ - 10 - - -50 ΔIIO/ΔΤ - 10 - - -50 VICR 0 - 28.3 0 - VIDR - - VCC - - - - - - - - - - - -	Symbol Min Typ Max Min Typ Max VIO - 2.0 5.0 - 2.0 7.0 - - 2.0 5.0 - 2.0 7.0 - - - 7.0 - - 9.0 ΔVΙΟ/ΔΤ - 7.0 - - 9.0 IIO - 3.0 30 - 5.0 50 IIB - - - 150 - <td>Symbol LM258 LM358 Max Min Typ Max Min VIO Min Typ Max Min Typ Max Min VIO - 2.0 5.0 - 2.0 7.0 - AVIO/ΔT - 7.0 - - 9.0 - IIO - 3.0 30 - - 0.0 - IIB - -45 -150 - -45 -250 - IIB - -45 -150 - -45 -250 - VICR 0 - 28.3 0 - 28.3 0 VIDR - - VCC - - VCC - AVOL 50 100 - 25 100 - 25 CS - -120 - - -</td> <td>Symbol LM258 LM2904 VIO Min Typ Max Min Typ Max Min Typ VIO - 2.0 5.0 - 2.0 7.0 - 2.0 - - - 7.0 - - 9.0 - - - - - 7.0 - - 9.0 - - ΔVIO/ΔΤ - 3.0 30 - 5.0 50 - 5.0 IIB - -45 -150 - -45 -250 - - -50 ΔIΙΟ/ΔΤ - 10 - - - -50 -500 - - -50 ΔΙΙΟ/ΔΤ - 10 -<!--</td--><td>Symbol Min Typ Max - 2.0 5.0 - 2.0 7.0 - 2.0 7.0 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 250 - 45 200 - 28 20 - 250 - 45 220 - 25 - 45 220 - 25 - 45 220 - 25 20 - 28.3 0 -</td><td> Symbol Min Typ Max Min Typ Max Min Typ Max Min Min </td><td>Symbol Min Typ Max Min Typ Min Typ Max Min Typ Min Min Typ Min Min Typ Min Typ Min Typ Min Typ Min Typ</td><td>Symbol Min Typ Max Min July Min Typ Max Min July Max Min Typ Max M</td></td>	Symbol LM258 LM358 Max Min Typ Max Min VIO Min Typ Max Min Typ Max Min VIO - 2.0 5.0 - 2.0 7.0 - AVIO/ΔT - 7.0 - - 9.0 - IIO - 3.0 30 - - 0.0 - IIB - -45 -150 - -45 -250 - IIB - -45 -150 - -45 -250 - VICR 0 - 28.3 0 - 28.3 0 VIDR - - VCC - - VCC - AVOL 50 100 - 25 100 - 25 CS - -120 - - -	Symbol LM258 LM2904 VIO Min Typ Max Min Typ Max Min Typ VIO - 2.0 5.0 - 2.0 7.0 - 2.0 - - - 7.0 - - 9.0 - - - - - 7.0 - - 9.0 - - ΔVIO/ΔΤ - 3.0 30 - 5.0 50 - 5.0 IIB - -45 -150 - -45 -250 - - -50 ΔIΙΟ/ΔΤ - 10 - - - -50 -500 - - -50 ΔΙΙΟ/ΔΤ - 10 - </td <td>Symbol Min Typ Max - 2.0 5.0 - 2.0 7.0 - 2.0 7.0 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 250 - 45 200 - 28 20 - 250 - 45 220 - 25 - 45 220 - 25 - 45 220 - 25 20 - 28.3 0 -</td> <td> Symbol Min Typ Max Min Typ Max Min Typ Max Min Min </td> <td>Symbol Min Typ Max Min Typ Min Typ Max Min Typ Min Min Typ Min Min Typ Min Typ Min Typ Min Typ Min Typ</td> <td>Symbol Min Typ Max Min July Min Typ Max Min July Max Min Typ Max M</td>	Symbol Min Typ Max - 2.0 5.0 - 2.0 7.0 - 2.0 7.0 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 250 - 45 200 - 28 20 - 250 - 45 220 - 25 - 45 220 - 25 - 45 220 - 25 20 - 28.3 0 -	Symbol Min Typ Max Min Typ Max Min Typ Max Min Min	Symbol Min Typ Max Min Typ Min Typ Max Min Typ Min Min Typ Min Min Typ Min Typ Min Typ Min Typ Min Typ	Symbol Min Typ Max Min July Min Typ Max Min July Max Min Typ Max M

 $T_{high} = +105^{\circ}C \text{ for LM2904}$ **NOTES:** 1. $T_{low} = -40^{\circ}C$ for LM2904 = -40°C for LM2904V = +125°C for LM2904V = -25°C for LM258 = +85°C for LM258 = 0°C for LM358 = +70°C for LM358

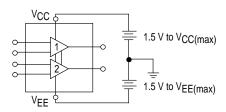
^{= +/0°}C for LM358

2. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} -1.7 V.

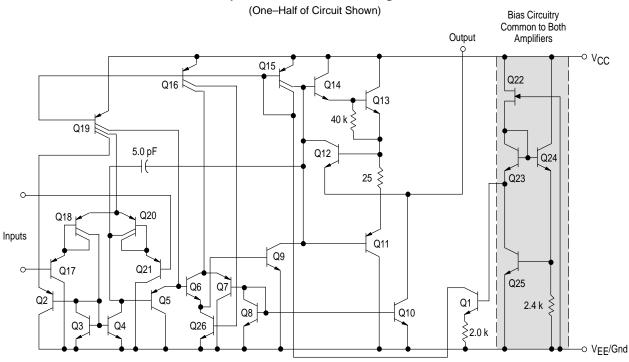
3. Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Single Supply 3.0 V to VCC(max) VCC VCC VCC VCC

Split Supplies



Representative Schematic Diagram



CIRCUIT DESCRIPTION

The LM258 series is made using two internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single-ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal-voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

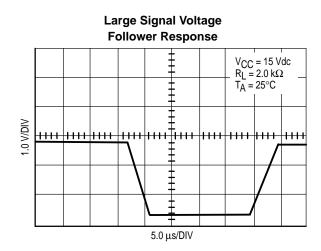
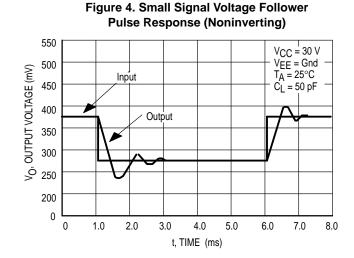
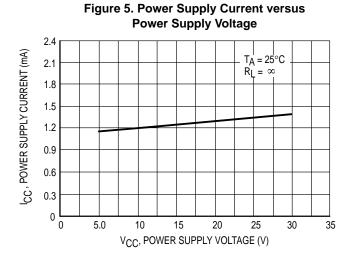


Figure 1. Input Voltage Range 20 18 16 V_I, INPUT VOLTAGE (V) 14 12 10 Negative 8.0 Positive 6.0 4.0 2.0 2.0 16 18 20 0 4.0 6.0 8.0 10 12 14 VCC/VEE. POWER SUPPLY VOLTAGES (V)

Figure 2. Large-Signal Open Loop Voltage Gain 120 A_{VOL}, OPEN LOOP VOLTAGE GAIN (dB) 100 VEE = Gnd T_A = 25°C 80 60 40 20 0 10 1.0 k 100 k 1.0 M 1.0 f, FREQUENCY (Hz)

Figure 3. Large-Signal Frequency Response 14 VOR, OUTPUT VOLTAGE RANGE (Vpp) $R_L = 2.0 \text{ k}\Omega$ 12 $V_{CC} = 15 V$ VEE = Gnd 10 Gain = -100 $R_I = 1.0 \text{ k}\Omega$ 8.0 $R_F = 100 \text{ k}\Omega$ 6.0 4.0 2.0 0 1.0 1000 f, FREQUENCY (kHz)





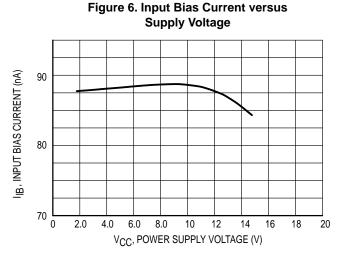


Figure 7. Voltage Reference

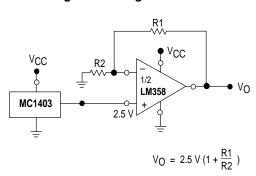


Figure 8. Wien Bridge Oscillator

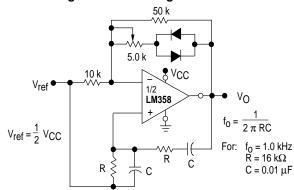


Figure 9. High Impedance Differential Amplifier

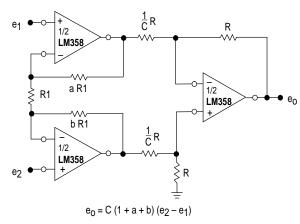


Figure 10. Comparator with Hysteresis

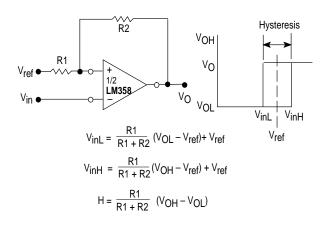


Figure 11. Bi-Quad Filter

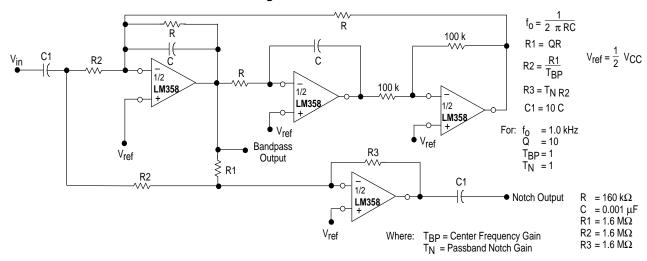
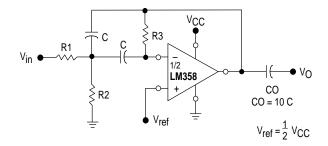


Figure 12. Function Generator

Triangle Wave Output • $V_{ref} = \frac{1}{2} V_{CC}$ R2 300 k R3 ∕∕∕∕∕− 75 k 1/2 LM358 LM358 R1 Square }100 <u>k</u> Wave _c |(V_{ref} • Output R_{f} $f = \frac{R1 + R_C}{4 \, CR_f \, R1}$ if, R3 = $\frac{R2 R1}{R2 + R1}$

Figure 13. Multiple Feedback Bandpass Filter



Given: f_0 = center frequency $A(f_0)$ = gain at center frequency

Choose value f₀, C

Then:
$$R3 = \frac{Q}{\pi\,f_0\,C}$$

$$R1 = \frac{R3}{2\,A(f_0)}$$

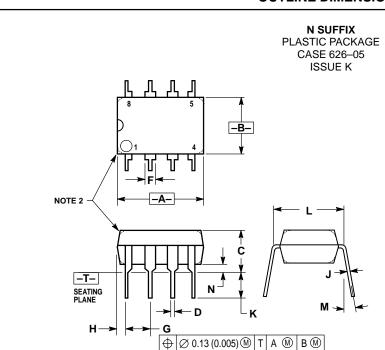
$$R2 = \frac{R1\,R3}{4Q^2\,R1\,-R3}$$

For less than 10% error from operational amplifier. $\frac{Q_0 f_0}{BW} < 0.1$

Where f_0 and BW are expressed in Hz.

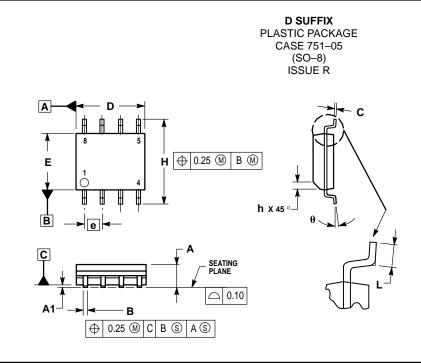
If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

OUTLINE DIMENSIONS



- 1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
- PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
- 3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

	MILLIN	IETERS	INCHES			
DIM	MIN	MIN MAX MIN		MAX		
Α	9.40	10.16	0.370	0.400		
В	6.10	6.60	0.240	0.260		
С	3.94	4.45	0.155	0.175		
D	0.38	0.51	0.015	0.020		
F	1.02	1.78	0.040	0.070		
G	2.54	BSC	0.100 BSC			
Н	0.76	1.27	0.030	0.050		
J	0.20	0.30	0.008	0.012		
K	2.92	3.43	0.115	0.135		
L	7.62	BSC	0.300 BSC			
M		10°		10°		
N	0.76	1.01	0.030	0.040		



- NOTES:

 1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.

 2. DIMENSIONS ARE IN MILLIMETERS.

 3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.

 4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

 5. DIMENSION B DOES NOT INCLUDE MOLD PROTRUSION ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION. CONDITION.

	MILLIMETERS						
DIM	MIN MAX						
Α	1.35	1.75					
A1	0.10	0.25					
В	0.35	0.49					
C	0.18	0.25					
D	4.80	5.00					
Е	3.80	4.00					
е	1.27	1.27 BSC					
Н	5.80	6.20					
h	0.25	0.50					
L	0.40	1.25					
Δ	nο	70					

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