

## Low noise dual operational amplifier

Datasheet – production data

### Features

- Low voltage noise: 4.5 nV/ $\sqrt{\text{Hz}}$
- High gain bandwidth product: 15 MHz
- High slew rate: 7 V/ $\mu\text{s}$
- Low distortion: 0.002%
- Large output voltage swing: +14.3 V / -14.6 V
- Low input offset voltage
- Excellent frequency stability
- ESD protection 2 kV
- Macromodel included in this specification

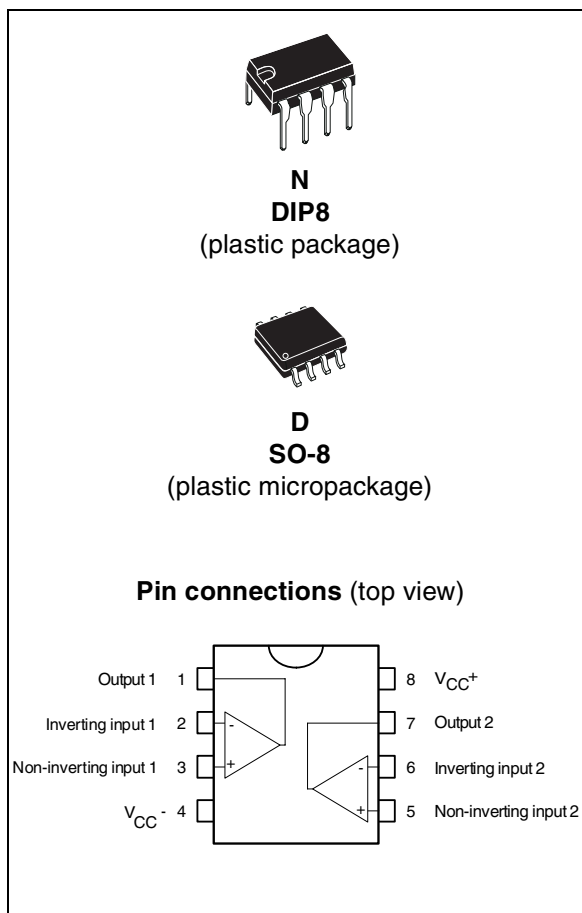
### Description

The MC33078 device is a monolithic dual operational amplifier particularly well suited for audio applications.

It offers low voltage noise (4.5 nV/ $\sqrt{\text{Hz}}$ ) and high frequency performance (15 MHz gain bandwidth product, 7 V/ $\mu\text{s}$  slew rate).

In addition, the MC33078 device has a very low distortion (0.002%) and excellent phase/gain margins.

The output stage allows a large output voltage swing and symmetrical source and sink currents.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings (AMR)**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage	±18 or +36	V
V <sub>id</sub>	Differential input voltage <sup>(1)</sup>	±30	V
V <sub>i</sub>	Input voltage <sup>(1)</sup>	±15	V
	Output short-circuit duration	Infinite	s
T <sub>j</sub>	Junction temperature	+150	°C
T <sub>stg</sub>	Storage temperature	-65 to +150	°C
R <sub>thja</sub>	Thermal resistance junction-to-ambient <sup>(2), (3)</sup>		°C/W
	SO-8	125	
	DIP8	85	
R <sub>thjc</sub>	Thermal resistance junction-to-case <sup>(2), (3)</sup>		°C/W
	SO-8	40	
	DIP8	41	
ESD	HBM: human body model <sup>(4)</sup>	2	kV
	MM: machine model <sup>(5)</sup>	200	V
	CDM: charged device model <sup>(6)</sup>	1.5	kV

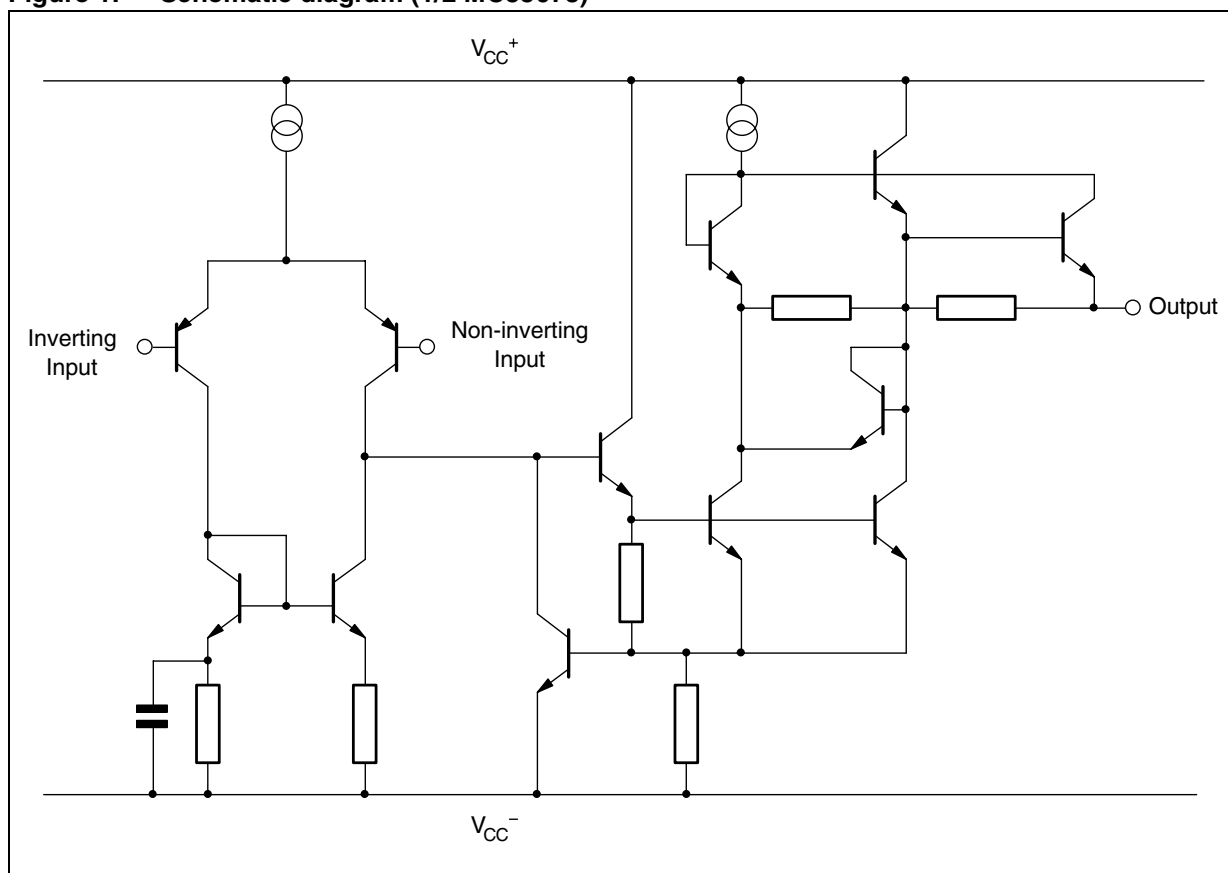
1. Either or both input voltages must not exceed the magnitude of V<sub>CC</sub><sup>+</sup> or V<sub>CC</sub><sup>-</sup>.
2. Short-circuits can cause excessive heating and destructive dissipation.
3. R<sub>th</sub> are typical values.
4. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
5. Machine model: A 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
6. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage	±2.5 to ±15	V
T <sub>oper</sub>	Operating free air temperature range	-40 to 125	°C

## 2 Schematic diagram

Figure 1. Schematic diagram (1/2 MC33078)



### 3 Electrical characteristics

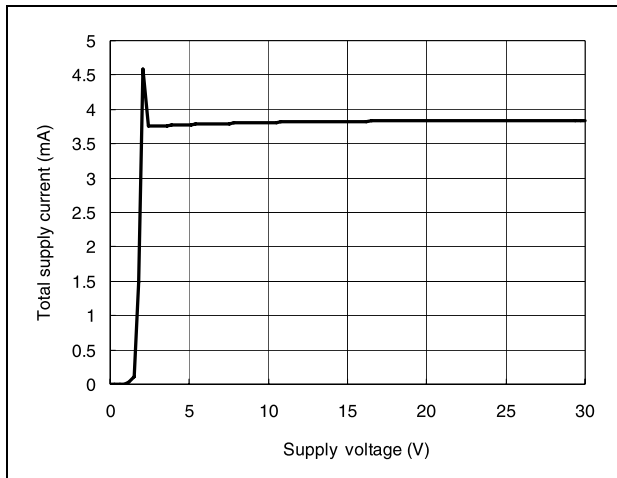
**Table 3.**  $V_{CC^+} = +15\text{ V}$ ,  $V_{CC^-} = -15\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage ( $V_o = 0\text{ V}$ , $V_{ic} = 0\text{ V}$ ) $T_{min} \leq T_{amb} \leq T_{max}$		0.15	2 3	mV
$\Delta V_{io}$	Input offset voltage drift $V_o = 0\text{ V}$ , $V_{ic} = 0\text{ V}$ , $T_{min} \leq T_{amb} \leq T_{max}$		2		$\mu\text{V}/^\circ\text{C}$
$I_{io}$	Input offset current ( $V_o = 0\text{ V}$ , $V_{ic} = 0\text{ V}$ ) $T_{min} \leq T_{amb} \leq T_{max}$		10	150 175	nA
$I_{ib}$	Input bias current ( $V_o = 0\text{ V}$ , $V_{ic} = 0\text{ V}$ ) $T_{min} \leq T_{amb} \leq T_{max}$		250	750 800	nA
$V_{icm}$	Input common mode voltage range ( $\Delta V_{io} = 5\text{ mV}$ , $V_o = 0\text{ V}$ )	$\pm 13$	$\pm 14$		V
$A_{vd}$	Large signal voltage gain ( $R_L = 2\text{ k}\Omega$ , $V_o = \pm 10\text{ V}$ ) $T_{min} \leq T_{amb} \leq T_{max}$	90 85	100		dB
$\pm V_{opp}$	Output voltage swing ( $V_{id} = \pm 1\text{ V}$ ) $R_L = 600\ \Omega$ $R_L = 600\ \Omega$ $R_L = 2.0\text{ k}\Omega$ $R_L = 2.0\text{ k}\Omega$ $R_L = 10\text{ k}\Omega$ $R_L = 10\text{ k}\Omega$	13.2 13.5	12.2 -12.7 14 -14.2 14.3 -14.6	-13.2 -14	V
CMR	Common mode rejection ratio ( $V_{ic} = \pm 13\text{ V}$ )	80	100		dB
SVR	Supply voltage rejection ratio $V_{CC^+} / V_{CC^-} = +15\text{ V} / -15\text{ V}$ to $+5\text{ V} / -5\text{ V}$	80	105		dB
$I_o$	Output short-circuit current ( $V_{id} = \pm 1\text{ V}$ , output to ground) Source Sink	15 20	29 37		mA
$I_{CC}$	Supply current ( $V_o = 0\text{ V}$ , all amplifiers) $T_{min} \leq T_{amb} \leq T_{max}$		4	5 5.5	mA
SR	Slew rate $V_i = -10\text{ V}$ to $+10\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = +1$	5	7		V/ $\mu\text{s}$
GBP	Gain bandwidth product $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$	10	15		MHz
B	Unity gain bandwidth (open loop)		9		MHz
$A_m$	Gain margin ( $R_L = 2\text{ k}\Omega$ , $C_L = 0\text{ pF}$ ) $C_L = 100\text{ pF}$		-11 -6		dB
$\phi_m$	Phase margin ( $R_L = 2\text{ k}\Omega$ , $C_L = 0\text{ pF}$ ) $C_L = 100\text{ pF}$		55 30		Degrees
$e_n$	Equivalent input noise voltage $R_S = 100\ \Omega$ , $f = 1\text{ kHz}$		4.5		nV/ $\sqrt{\text{Hz}}$
$i_n$	Equivalent input noise current ( $f = 1\text{ kHz}$ )		0.5		pA/ $\sqrt{\text{Hz}}$

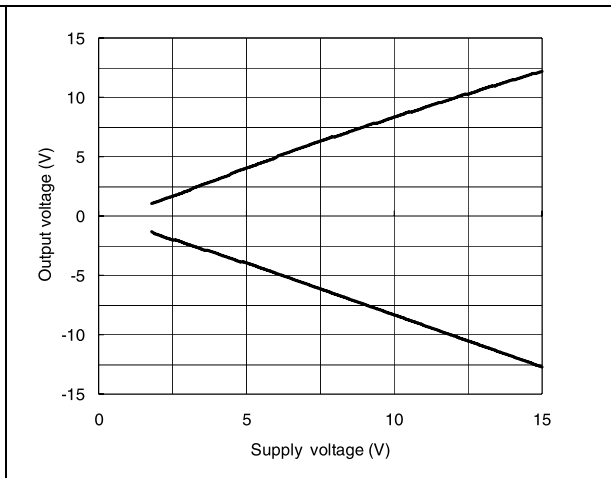
Table 3.  $V_{CC}^+ = +15\text{ V}$ ,  $V_{CC}^- = -15\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified) (continued)

Symbol	Parameter	Min.	Typ.	Max.	Unit
THD	Total harmonic distortion $R_L = 2\text{ k}\Omega$ , $f = 20\text{ Hz to }20\text{ kHz}$ , $V_o = 3\text{ V}_{rms}$ , $A_V = +1$		0.002		%
$V_{O1}/V_{O2}$	Channel separation $f = 20\text{ Hz to }20\text{ kHz}$		120		dB
FPB	Full power bandwidth $V_o = 27\text{ V}_{pp}$ , $R_L = 2\text{ k}\Omega$ , $THD \leq 1\%$		120		kHz
$Z_o$	Output impedance $V_o = 0\text{ V}$ , $f = 9\text{ MHz}$		37		$\Omega$
$R_i$	Input resistance $V_{ic} = 0\text{ V}$		175		$\text{k}\Omega$
$C_i$	Input capacitance $V_{ic} = 0\text{ V}$		12		pF

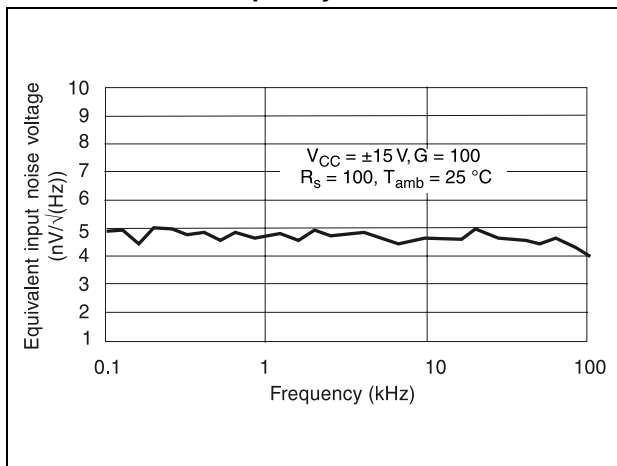
**Figure 2. Total supply current vs. supply voltage**



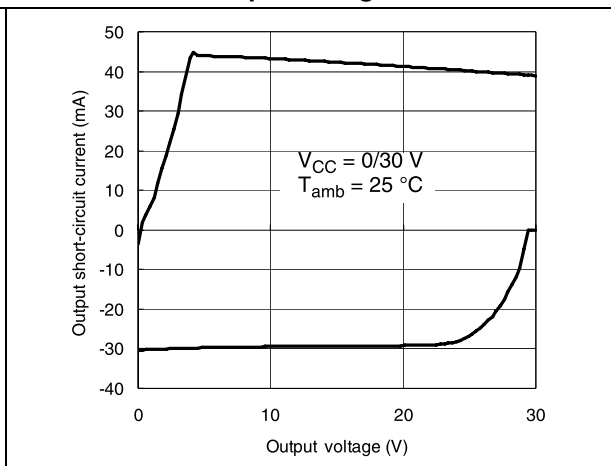
**Figure 3. Output voltage vs. supply voltage**



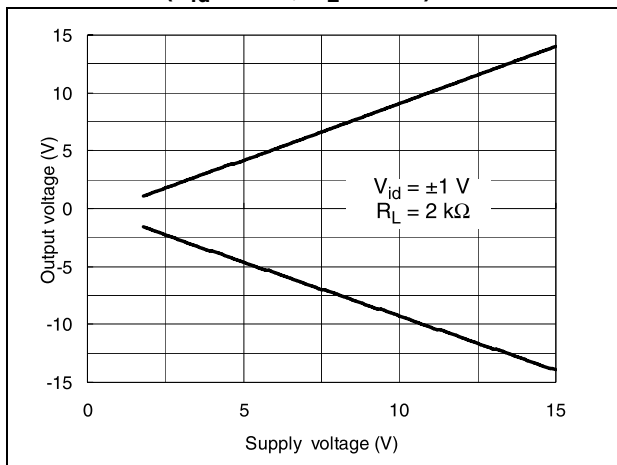
**Figure 4. Equivalent input noise voltage vs. frequency**



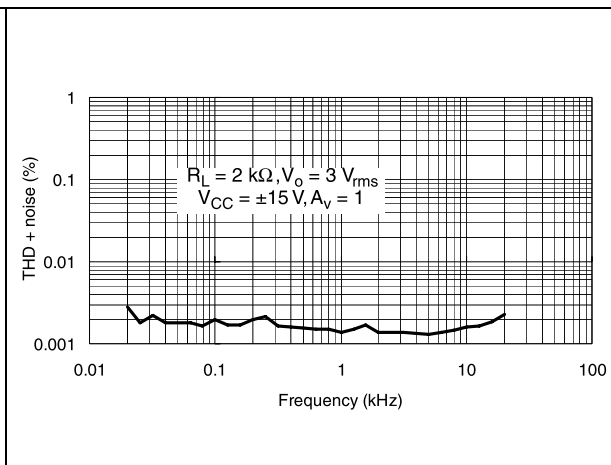
**Figure 5. Output short-circuit current vs. output voltage**



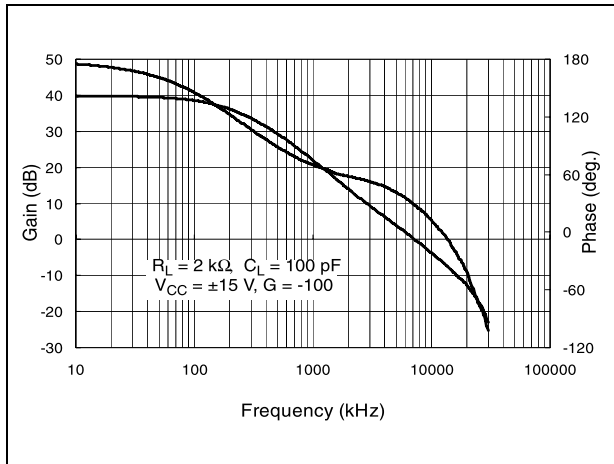
**Figure 6. Output voltage vs. supply voltage ( $V_{id} = \pm 1\text{ V}, R_L = 2\text{ k}\Omega$ )**



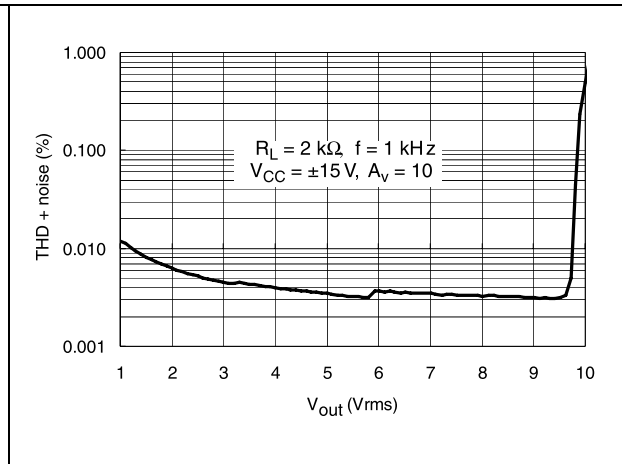
**Figure 7. THD + noise vs. frequency**



**Figure 8. Voltage gain and phase vs. frequency**



**Figure 9. THD noise vs.  $V_{out}$**



## 4 Macromodel

### 4.1 Important note concerning this macromodel

Please consider the following remarks before using this macromodel.

- All models are a trade-off between accuracy and complexity (i.e. simulation time).
- Macromodels are not a substitute to breadboarding; rather, they confirm the validity of a design approach and help to select surrounding component values.
- A macromodel emulates the **nominal** performance of a **typical** device within **specified operating conditions** (temperature, supply voltage, for example). Thus the macromodel is often not as exhaustive as the datasheet, its purpose is to illustrate the main parameters of the product.

Data derived from macromodels used outside of the specified conditions ( $V_{CC}$ , temperature, for example) or even worse, outside of the device operating conditions ( $V_{CC}$ ,  $V_{icm}$ , for example), is not reliable in any way.

[Section 4.2](#) provides the electrical characteristics resulting from the use of this macromodel.

### 4.2 Electrical characteristics from macromodelization

**Table 4. Electrical characteristics resulting from macromodel simulation at  $V_{CC}^+ = +15\text{ V}$ ,  $V_{CC}^- = -15\text{ V}$ ,  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)**

Symbol	Conditions	Value	Unit
$V_{io}$		0	mV
$A_{VD}$	$R_L = 2\text{ k}\Omega$ , $V_O = \pm 10\text{ V}$	100	dB
$I_{CC}$	No load, per operator	2	mA
$V_{icm}$	$\Delta V_{io} = 5\text{ mV}$ , $V_O = 0\text{ V}$	28	V
$V_{opp}$	$R_L = 2\text{ k}\Omega$	28.2	V
$I_{sink}$	$V_O = 0\text{ V}$	37	mA
$I_{source}$	$V_O = 0\text{ V}$	29	mA
GBP	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	15	MHz
SR	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = +1$	7	V/ $\mu$ s
$\phi_m$	$R_L = 2\text{ k}\Omega$ , $C_L = 0\text{ pF}$	55	Degrees



### 4.3 Macromodel code

```

** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT MC33078 1 3 2 4 5
*****
.MODEL MDTH D IS=1E-8 KF=2.286238E-16 CJO=10F
* INPUT STAGE
CIP 2 5 1.200000E-11
CIN 1 5 1.200000E-11
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 2.363636E+00
RIN 15 16 2.363636E+00
RIS 11 15 1.224040E+01
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0
VOFN 13 14 DC 0
IPOL 13 5 1.100000E-04
CPS 11 15 2.35E-09
DINN 17 13 MDTH 400E-12
VIN 17 5 1.000000E+00
DINR 15 18 MDTH 400E-12
VIP 4 18 1.000000E+00
FCP 4 5 VOFP 1.718182E+01
FCN 5 4 VOFN 1.718182E+01
FIBP 2 5 VOFN 4.545455E-03
FIBN 5 1 VOFP 4.545455E-03
* AMPLIFYING STAGE
FIP 5 19 VOFP 9.545455E+02
FIN 5 19 VOFN 9.545455E+02
CC 19 29 1.500000E-08
HZTP 30 29 VOFP 1.523529E+02
HZTN 5 30 VOFN 1.523529E+02
DOPM 51 22 MDTH 400E-12
DONM 21 52 MDTH 400E-12
HOPM 22 28 VOUT 5.172414E+03
VIPM 28 4 1.500000E+02
HONM 21 27 VOUT 4.054054E+03

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```
VINM 5 27 1.500000E+02
DBIDON1 19 53 MDTH 400E-12
V1 51 53 0.68
DBIDON2 54 19 MDTH 400E-12
V2 54 52 0.68
RG11 51 5 3.04E+05
RG12 51 4 3.04E+05
RG21 52 5 0.6072E+05
RG22 52 4 0.6072E+05
E1 50 40 51 0 1 E2 40 39 52 0 1
EDEC1 38 39 4 0 0.5
EDEC2 0 38 5 0 0.5
DOP 51 25 MDTH 400E-12
VOP 4 25 1.474575E+00
DON 24 52 MDTH 400E-12
VON 24 5 1.474575E+00
RAJUS 50 5 1E12
GCOMP 5 4 4 5 8.1566068E-04
RPM1 5 80 1E+06
RPM2 4 80 1E+06
GAVPH 5 82 50 80 3.26E-03
RAVPHGH 82 4 613
RAVPHGB 82 5 613
RAVPHDH 82 83 1000
RAVPHDB 82 84 1000
CAVPHH 4 83 0.159E-09
CAVPHB 5 84 0.159E-09
EOUT 26 23 82 5 1
VOUT 23 5 0
ROUT 26 3 4.780354E+01
COUT 3 5 1.000000E-12
.ENDS
```

## 5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

## 5.1 DIP8 package information

Figure 10. DIP8 package outline

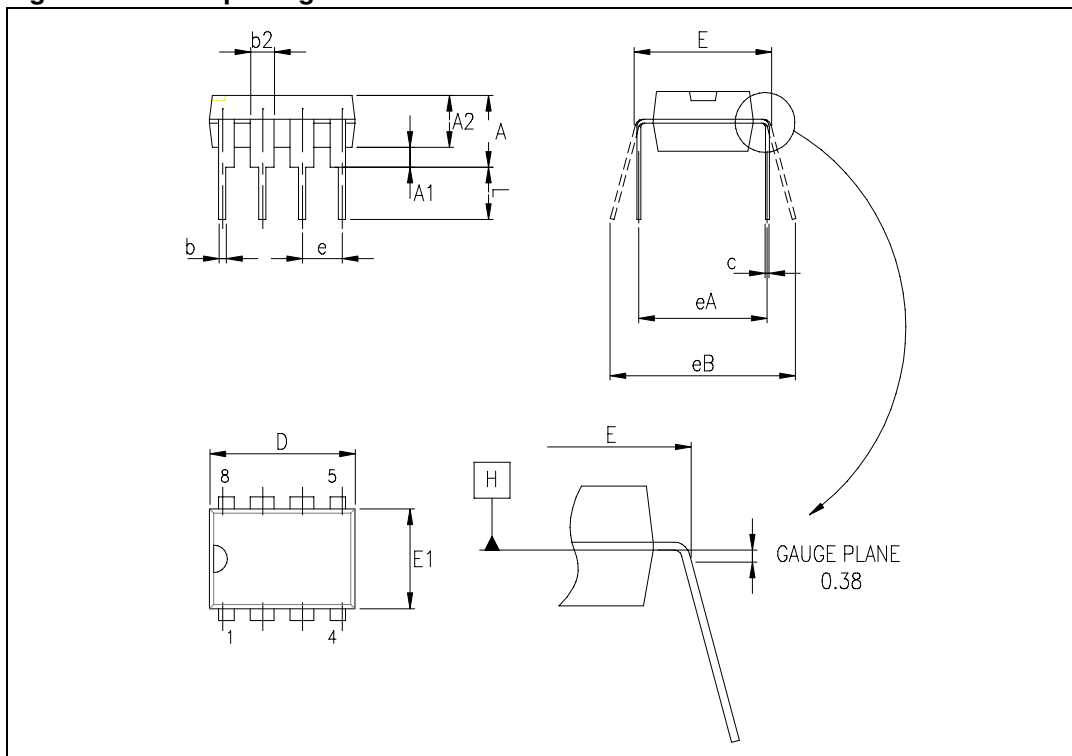


Table 5. DIP8 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.33			0.210
A1	0.38			0.015		
A2	2.92	3.30	4.95	0.115	0.130	0.195
b	0.36	0.46	0.56	0.014	0.018	0.022
b2	1.14	1.52	1.78	0.045	0.060	0.070
c	0.20	0.25	0.36	0.008	0.010	0.014
D	9.02	9.27	10.16	0.355	0.365	0.400
E	7.62	7.87	8.26	0.300	0.310	0.325
E1	6.10	6.35	7.11	0.240	0.250	0.280
e		2.54			0.100	
eA		7.62			0.300	
eB			10.92			0.430
L	2.92	3.30	3.81	0.115	0.130	0.150

## 5.2 SO-8 package information

Figure 11. SO-8 package outline

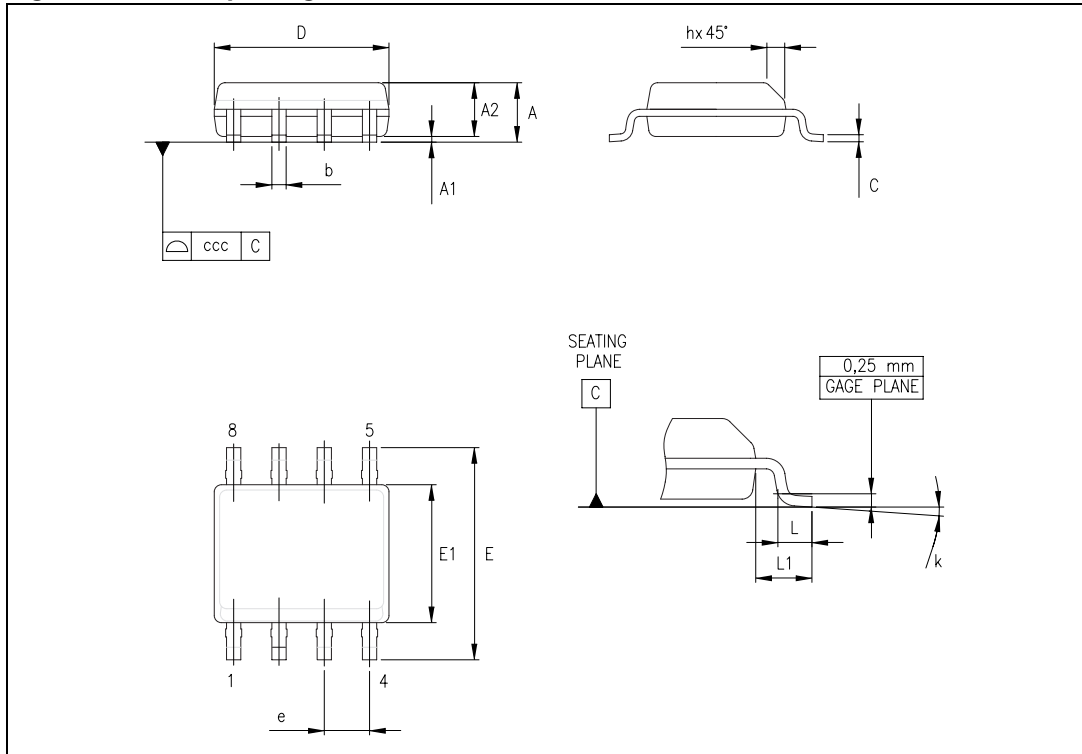


Table 6. SO-8 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28	0.40	0.48	0.011	0.016	0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40	0.635	1.27	0.016	0.025	0.050
k	1°		8°	1°		8°
ccc			0.10			0.004

## 6 Ordering information

**Table 7. Order codes**

Order code	Temperature range	Package	Packaging	Marking
MC33078N	-40, +125 °C	DIP8	Tube	MC33078N
MC33078D MC33078DT		SO-8	Tube or tape and reel	33078
MC33078YDT <sup>(1)</sup>		SO-8 (automotive grade)	Tube or tape and reel	33078Y

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

## 7 Revision history

**Table 8. Document revision history**

Date	Revision	Changes
10-Nov-2001	1	Initial release.
10-Jun-2005	2	PPAP references inserted in the datasheet, see order codes table.
30-Sep- 2005	3	The following changes were made in this revision: – Order codes table updated with complete list of markings and packages. – Reorganization of <a href="#">Chapter 4.3: Macromodel code on page 9</a> .
16-Feb-2006	4	Corrected error in the first page title.
3-Mar-2008	5	Added R <sub>th</sub> and ESD values in absolute maximum ratings table. Added footnote for automotive grade order codes in order codes table. Re-formatted document.
13-Nov-2012	6	Added conditions to title of <a href="#">Figure 6</a> . Updated temperature range in <a href="#">Table 2</a> and <a href="#">Table 7</a> . Updated ECOPACK text in <a href="#">Section 5</a> . Updated <a href="#">Table 6</a> (added “b” and “L” typ. dimensions). Qualified status of the MC33078YDT order code, removed the MC33078YD order code from <a href="#">Table 7</a> . Minor corrections throughout document.

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