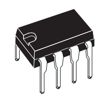
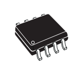
LS204

HIGH PERFORMANCE DUAL OPERATIONAL AMPLIFIER

- LOW POWER CONSUMPTION
- SHORT CIRCUIT PROTECTION
- LOW DISTORTION, LOW NOISE
- HIGH GAIN-BANDWIDTH PRODUCT
- HIGH CHANNEL SEPARATION



N
DIP8
(Plastic Package)



D
SO8
(Plastic Micropackage)

DESCRIPTION

The LS204 is a high performance dual operational amplifier with frequency and phase compensation built into the chip. The internal phase compensation allows stable operation as voltage follower in spite of its high Gain-Bandwidth Product.

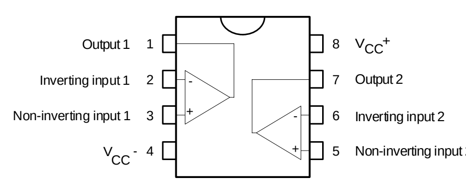
The circuit presents very stable electrical characteristics over the entire supply voltage range, and is particularly intended for professional and telecom applications (active filter, etc).

ORDER CODE

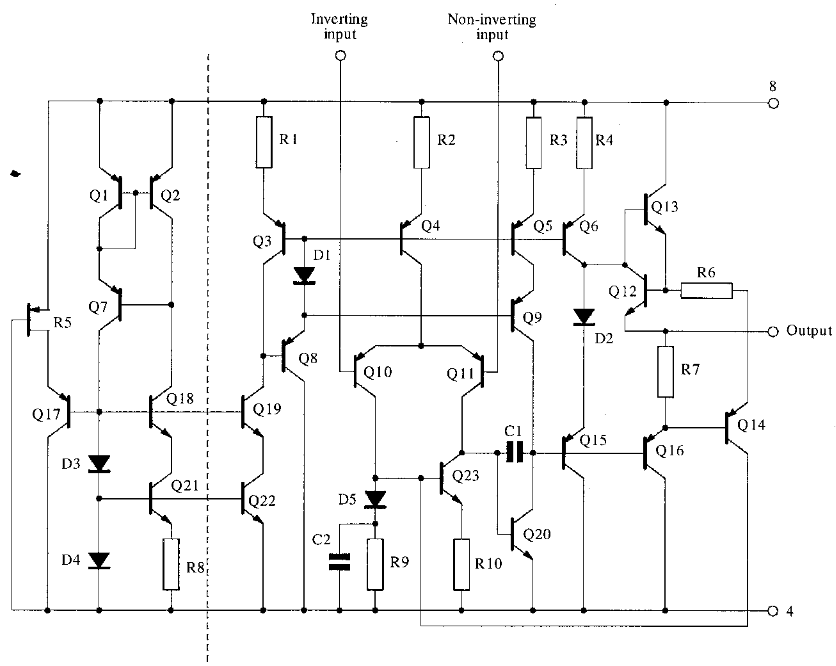
Part Number	Temperature Range	Package	
		N	D
LS204C	0°C, +70°C	•	•
LS204I	-40°C, +105°C	•	•
Example : LS204CN			

N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/2 LS204)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	±18	V
V_i	Input Voltage	$\pm V_{CC}$	V
V_{id}	Differential Input Voltage	$\pm(V_{CC}$ -1)	V
T_{oper}	Operating Temperature Range LS204C LS204I	0 to +70 -40 to +105	°C
P_{tot}	Power Dissipation at T_{amb} = 70°C [1)]	500	mW
T_J	Junction Temperature	150	°C
T_{stg}	Storage Temperature Range	-65 to +150	°C

1. Power dissipation must be considered to ensure maximum junction temperature (Tj) is not exceeded.

ELECTRICAL CHARACTERISTICS

V_{CC} = ±15V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	LS204I			LS204C			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
I_{cc}	Supply Current		0.7	1.2		0.8	1.5	mA
I_{ib}	Input Bias Current T_{amb} = 25°C $T_{min} < T_{op} < T_{max}$		50	150 300		100	300 700	nA
R_i	Input Resistance (f = 1kHz)		1			1		MΩ
V_{io}	Input Offset Voltage ($R_S \leq 10k\Omega$) T_{amb} = 25°C $T_{min} < T_{op} < T_{max}$		0.5	2.5 3.5		0.5	3.5 5	mV
DV_{io}	Input Offset Voltage Drift ($R_S \leq 10k\Omega$) $T_{min} < T_{op} < T_{max}$		5			5		µV/°C
I_{io}	Input Offset Current $T_{min} < T_{op} < T_{max}$		5	20 40		12	50 100	nA
DI_{io}	Input Offset Current Drift $T_{min} < T_{op} < T_{max}$		0.08			0.1		nA/°C
I_{os}	Output Short-circuit Current		23			23		mA
A_{vd}	Large Signal Voltage Gain $T_{min} < T_{op} < T_{max}$ R_L = 2kΩ V_{CC} = ±15V V_{CC} = ±4V	90	100 95		86	100 95		dB
GBP	Gain Bandwith Product (f =100kHz)	1.8	3		1.5	2.5		MHz
e_n	Equivalent Input Noise Voltage f = 1kHz, R_S = 100Ω R_s = 50Ω R_s = 1kΩ R_s = 10kΩ		8 10 18			10 12 20		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion (f = 1kHz, A_v = 20dB, R_L = 2kΩ, V_o = $2V_{pp}$)		0.03			0.03		%
$\pm V_{opp}$	Output Voltage Swing R_L = 2kΩ V_{CC} = ±15V V_{CC} = ±4V	±13	±3		±13	±3		V
V_{opp}	Large Signal Voltage Swing R_L = 10kΩ, f = 10kHz		28			28		Vpp
SR	Slew Rate (R_L = 2kΩ, unity gain)	0.8	1.5			1		V/µs
SVR	Supply Voltage Rejection Ratio $T_{min} < T_{op} < T_{max}$	90			86			dB
CMR	Common Mode Rejection Ratio V_{ic} = ±10V $T_{min} < T_{op} < T_{max}$	90			86			dB
V_{o1}/V_{o2}	Channel Separation (f= 1kHz)	100	120			120		dB

Figure 1 : Supply Current versus Supply Voltage

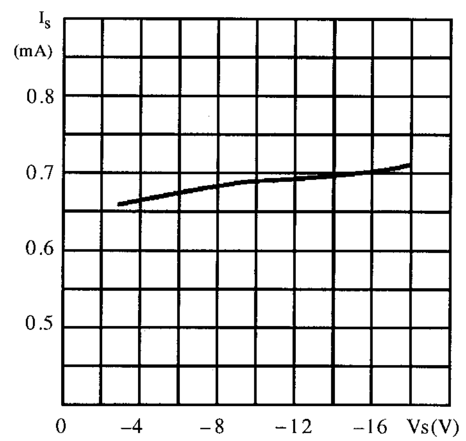


Figure 2 : Supply Current versus Ambient Temperature

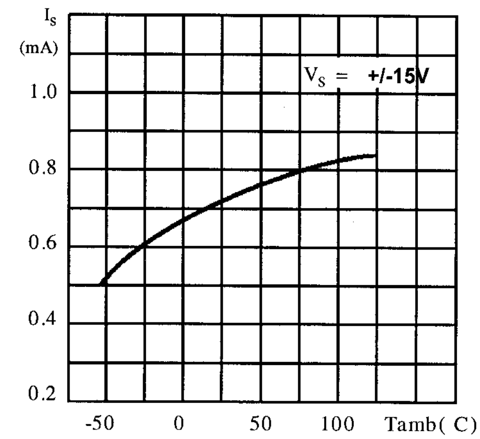


Figure 3 : Output Short Circuit Current versus Ambient Temperature

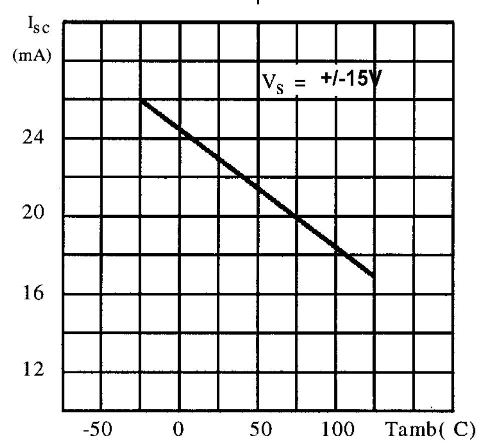


Figure 4 : Open Loop Frequency and Phase Response

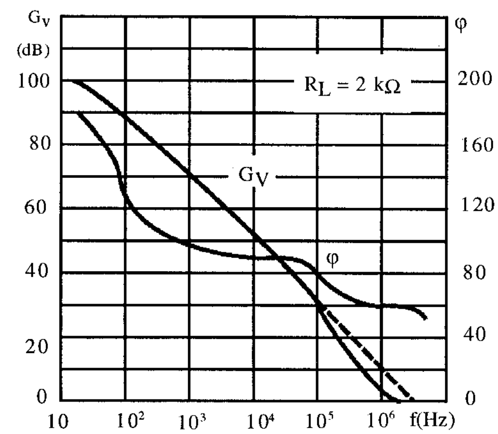


Figure 5 : Output Loop Gain versus Ambient Temperature

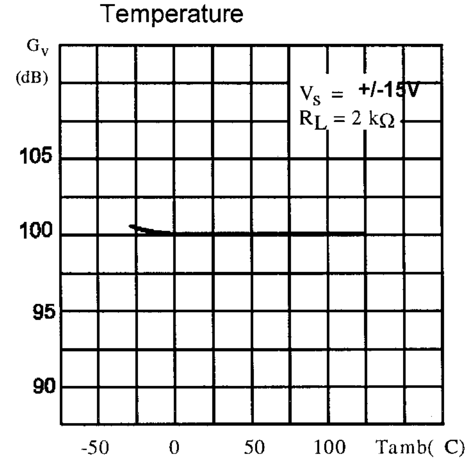


Figure 6 : Supply Voltage Rejection versus Frequency

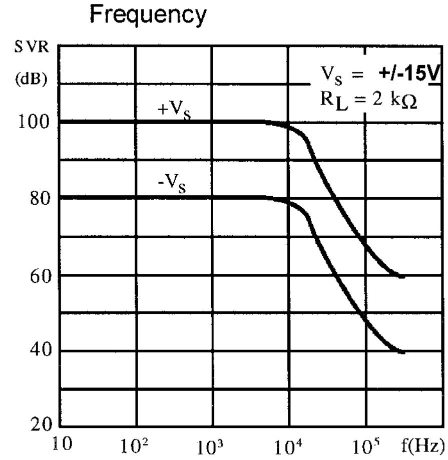


Figure 7 : Large Signal Frequency Response

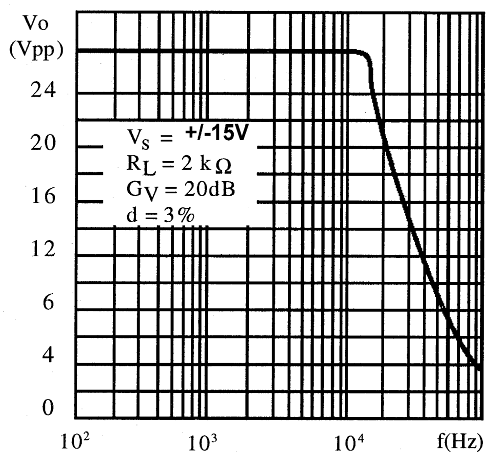


Figure 8 : Output Voltage Swing versus Load Resistance

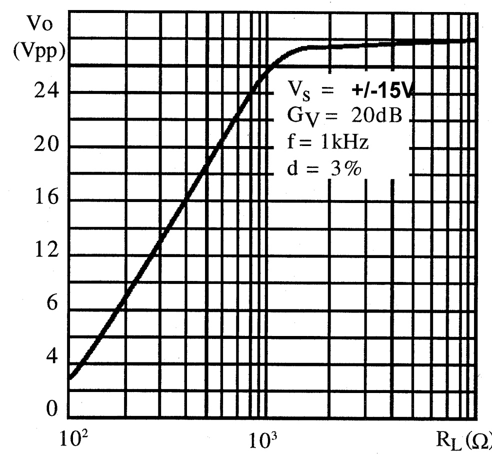


Figure 9 : Total Input Noise versus Frequency

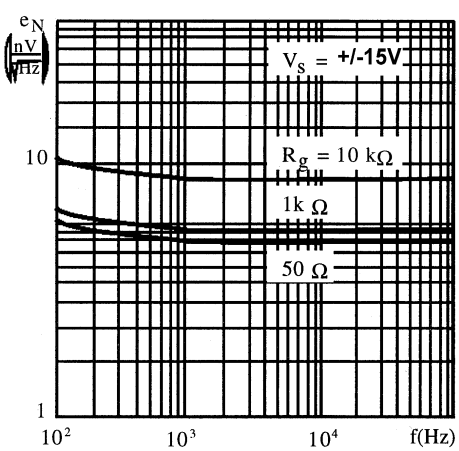


Figure 10 : Amplitude Response

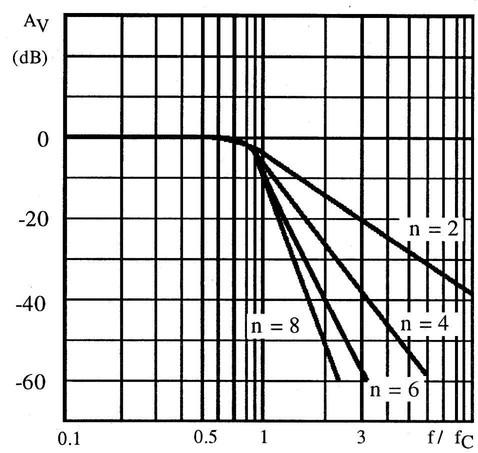
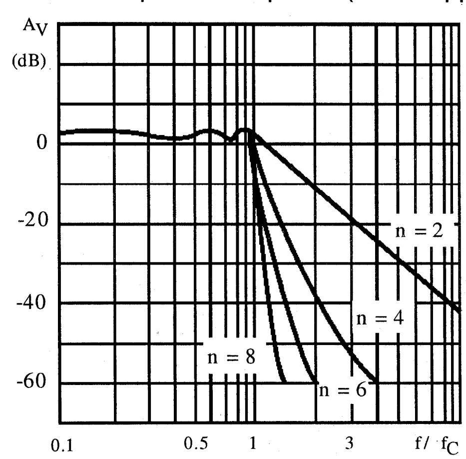


Figure 11 : Amplitude Response (±1dB ripple)



APPLICATION INFORMATION: Active low-pass filter

BUTTERWORTH

The Butterworth is a "maximally flat" amplitude response filter (figure 10) Butterworth filters are used for filtering signals in data acquisition systems to prevent aliasing errors in samples-data applications and for general purpose low-pass filtering.

The cut-off frequency Fc, is the frequency at which the amplitude response is down 3dB. The attenuation rate beyond the cutoff frequency is n6 dB per octave of frequency where n is the order (number of poles) of the filter.

Other characteristics :

- ❑ Flattest possible amplitude response
- ❑ Excellent gain accuracy at low frequency end of passband

BESSEL

The Bessel is a type of “linear phase” filter. Because of their linear phase characteristics, these filters approximate a constant time delay over a limited frequency range. Bessel filters pass transient waveforms with a minimum of distortion. They are also used to provide time delays for low pass filtering of modulated waveforms and as a “running average” type filter.

The maximum phase shift is $\frac{-n\pi}{2}$ radians where n is the order (number of poles) of the filter. The cut-off frequency fc, is defined as the frequency at which the phase shift is one half of this value.

For accurate delay, the cut-off frequency should be twice the maximum signal frequency.

The following table can be used to obtain the -3dB frequency of the filter.

	2 Pole	4 Pole	6 Pole	8 Pole
-3dB Frequency	0.77fc	0.67fc	0.57fc	0.50fc

Other characteristics :

- ❑ Selectivity not as great as Chebyschev or Butterworth
- ❑ Very little overshoot response to step inputs
- ❑ Fast rise time

CHEBYSCHEV

Chebyschev filters have greater selectivity than either Bessel ro Butterworth at the expense of ripple in the passband (figure 11).

Chebyschev filters are normally designed with peak-to-peak ripple values from 0.2dB to 2dB.

Increased ripple in the passband allows increased attenuation above the cut-off frequency.

The cut-off frequency is defined as the frequency at which the amplitude response passes through the specificed maximum ripple band and enters the stop band.

Other characteristics :

- ❑ Greater selectivity
- ❑ Very non-linear phase response
- ❑ High overshoot response to step inputs

The table below shows the typical overshoot and setting time response of the low pass filters to a step input.

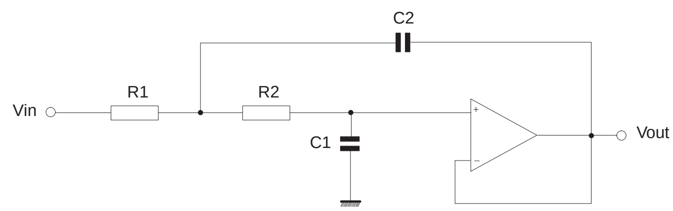
	Number of Poles	Peak Overshoot	Settling Time (% of final value)		
		% Overshoot	±1%	±0.1%	±0.01%
Butterworth	2	4	1.1Fc sec.	1.7Fc sec.	1.9Fc sec.
	4	11	1.7/fc	2.8/fc	3.8/fc
	6	14	2.4/fc	3.9S/fc	5.0S/fc
	8	14	3.1/fc	5.1/fc	7.1/fc
Bessel	2	0.4	0.8/fc	1.4/fc	1.7/fc
	4	0.8	1.0/fc	1.8/fc	2.4/fc
	6	0.6	1.3/fc	2.1/fc	2.7/fc
	8	0.1	1.6/fc	2.3/fc	3.2/fc
Chebyschev (ripple ±0.25dB)	2	11	1.1/fc	1.6/fc	-
	4	18	3.0/fc	5.4/fc	-
	6	21	5.9/fc	10.4/fc	-
	8	23	8.4/fc	16.4/fc	-
Chebyschev (ripple ±1dB)	2	21	1.6/fc	2.7/fc	
	4	28	4.8/fc	8.4/fc	-
	6	32	8.2/fc	16.3/fc	-
	8	34	11.6/fc	24.8/fc	-

Design of 2nd order active low pass filter (Sallen and Key configuration unity gain op-amp)

Fixed R = R1 = R2, we have (see figure 12)

$$C1 = \frac{1}{R}\frac{\zeta}{\omega c} \qquad C2 = \frac{1}{R}\frac{1}{\xi\omega c}$$

Figure 12 : Filter Configuration



Three parameters are needed to characterize the frequency and phase response of a 2nd order active filter: the gain (Gv), the damping factio (ξ) or the Q factor ($Q = 2\,\xi)^{1}$), and the cuttoff frequency (fc).

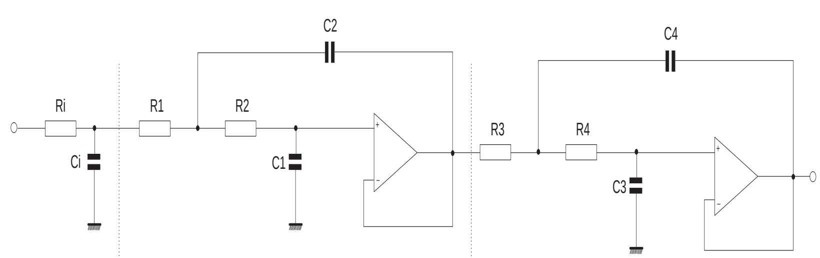
The higher order response are obtained with a series of 2nd order sections. A simple RC section is introduced when an odd filter is required.
The choice of 'ξ' (or Q factor) determines the filter response (see table 1).

Table 1

Filter Response	ξ	Q	Cuttoff Frequency fc
Bessel	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{1}}{3}$	Frequency at which Phase Shift is -90°C
Butterworth	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{1}}{2}$	Frequency at which Gv = -3dB
Chebyschev	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{1}}{2}$	Frequency at which the amplitude response passes through specified max. ripple band and enters the stop bank.

EXAMPLE

Figure 13 : 5th Order Low-pass Filter (Butterworth) with Unity Gain configuration



In the circuit of figure 13, for fc = 3.4kHz and R_i = R1 = R2 = R3 = 10kΩ, we obtain:

$$Ci = 1.354\ \frac{1}{R}\ \frac{1}{2\pi fc} = 6.33nF$$

$$C1 = 0.421\ \frac{1}{R}\ \frac{1}{2\pi fc} = 1.97nF$$

$$C2 = 1.753\ \frac{1}{R}\ \frac{1}{2\pi fc} = 8.20nF$$

$$C3 = 0.309\ \frac{1}{R}\ \frac{1}{2\pi fc} = 1.45nF$$

$$C4 = 3.325\ \frac{1}{R}\ \frac{1}{2\pi fc} = 15.14nF$$

The attenuation of the filter is 30dB at 6.8kHz and better than 60dB at 15kHz.

The same method, referring to table 2 and figure 14 is used to design high-pass filter. In this case the damping factor is found by taking the reciprocal of the numbers in table 2. For fc = 5kHz and Ci = C1 = C2 = C3 = 1nF we obtain:

$$Ri = \frac{1}{0.354}\ \frac{1}{C}\ \frac{1}{2\pi fc} = 25.5k\Omega$$

$$R1 = \frac{1}{0.421}\ \frac{1}{C}\ \frac{1}{2\pi fc} = 75.6k\Omega$$

$$R2 = \frac{1}{1.753}\ \frac{1}{C}\ \frac{1}{2\pi fc} = 18.2k\Omega$$

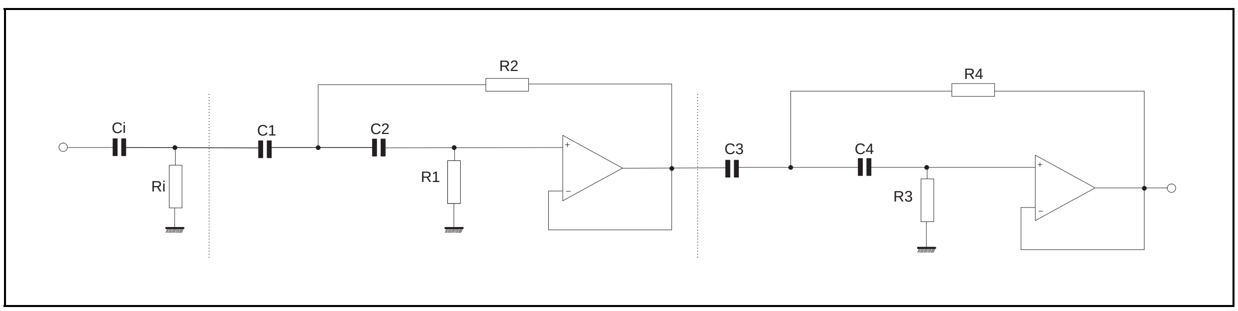
$$R3 = \frac{1}{0.309}\ \frac{1}{C}\ \frac{1}{2\pi fc} = 103k\Omega$$

$$R4 = \frac{1}{3.325}\ \frac{1}{C}\ \frac{1}{2\pi fc} = 9.6k\Omega$$

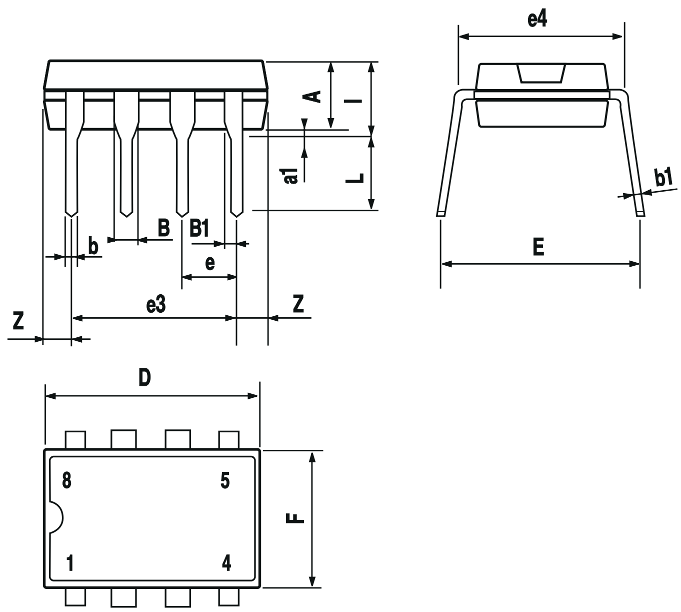
Table 2 : Damping Factor for Low-pass Butterworth Filters

Order	Ci	C1	C2	C3	C4	C5	C6	C7	C8
2		0.707	1.41						
3	1.392	0.202	3.54						
4		0.92	1.08	0.38	2.61				
5	1.354	0.421	1.75	0.309	3.235				
6		0.966	1.035	0.707	1.414	0.259	3.86		
7	1.336	0.488	1.53	0.623	1.604	0.222	4.49		
8		0.98	1.02	0.83	1.20	0.556	1.80	0.195	5.125

Figure 14 : 5th Order High-pass Filter (Butterworth) with Unity Gain configuration

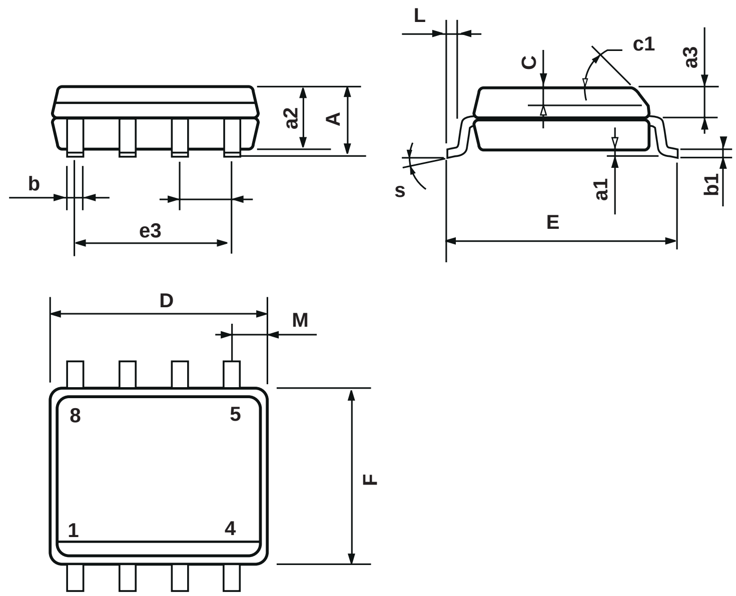


PACKAGE MECHANICAL DATA
8 PINS - PLASTIC PACKAGE



Dimensions	Millimeters			Inches		
	Min.	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

PACKAGE MECHANICAL DATA
8 PINS - PLASTIC MICROPACKAGE (SO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8° (max.)					

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