# LINEAR INTEGRATED CIRCUITS

**SGS** **LS148 LS148A LS148C**

## OPERATIONAL AMPLIFIERS

- SHORT CIRCUIT PROTECTION
- OFFSET VOLTAGE NULL CAPABILITY
- LARGE COMMON MODE AND DIFFERENTIAL VOLTAGE RANGE
- NO LATCH-UP
- SLEW-RATE = 5.5V/$\mu$s ($G_v$ = 10, $C_C$ = 3.5 pF)

The LS 148 series consists of general purpose operational amplifiers, intended for a wide range of analog applications where tailoring of frequency characteristics is desirable. High common mode voltage range and absence of "Latch-up" tendencies make the LS 148 series ideal for use as a voltage follower. The high gain and wide range of operating voltage provide superior performance in integrators, summing amplifiers and general feedback applications. Unity gain frequency compensation is achieved by means of a single 30 pF capacitor. The LS 148 series is available with hermetic gold chip (8000 series). This is particularly suitable for professional and telecom applications, wherever very high MTBF are required.

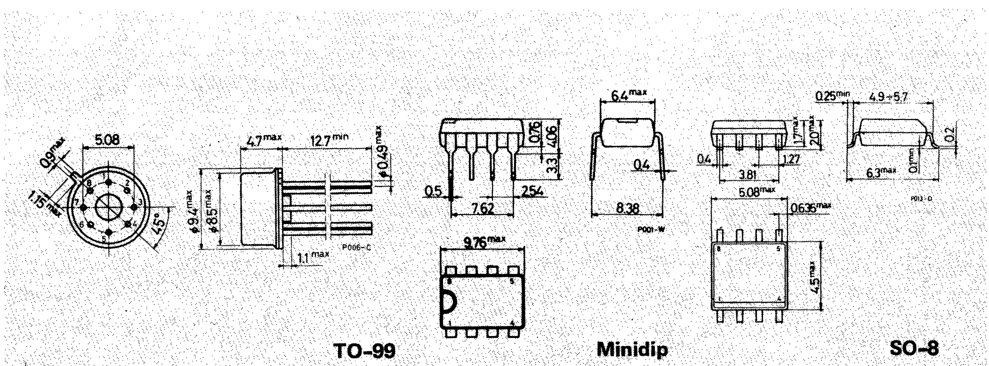
## ABSOLUTE MAXIMUM RATINGS

| | | TO-99 | Minidip | $\mu$package |
|---|---|---|---|---|
| $V_s$ | Supply voltage | | ± 22V | |
| $V_i$ (1) | Input voltage | | ± 15V | |
| $\Delta V_i$ | Differential input voltage | | ± 30V | |
| $T_{op}$ | Operating temperature for **LS 148/LS 148A** | | -55 to 125 °C | |
| | for **LS 148C** | | 0 to 70 °C | |
| | Output short circuit duration (2) | | indefinite | |
| $P_{tot}$ | Power dissipation at $T_{amb}$ = 70°C | 520 mW | 665 mW | 400 mW |
| $T_{stg}$ | Storage temperature | -65 to 150 °C | -55 to 150 °C | -55 to 150 °C |

1) For supply voltage less than ± 15V, input voltage is equal to the supply voltage
2) The short circuit duration is limited by thermal dissipation.

## MECHANICAL DATA

Dimensions in mm



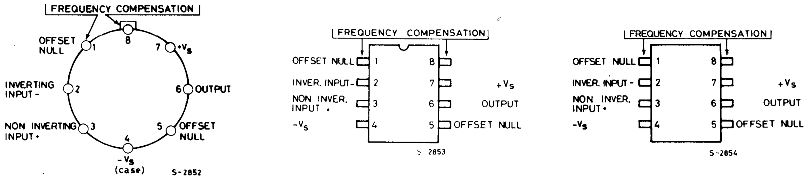
TO-99 Minidip SO-8



6/82

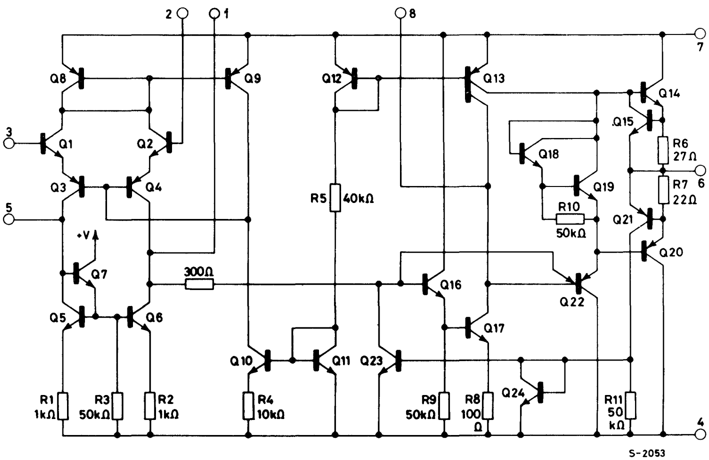
# LS148
# LS148A
# LS148C

## CONNECTION DIAGRAMS AND ORDERING NUMBERS
(top views)




| Type | TO-99 | Minidip | SO-8 |
|---|---|---|---|
| LS 148 | LS 148T | – | – |
| LS 148A | LS 148 AT | – | – |
| LS 148C | LS 148 CT | LS 148 CB | LS 148 CM |
| LS 8148 | – | – | LS 8148M |
| LS 8148A | – | – | LS 8148 AM |
| LS 8148C | – | – | LS 8148 CM |

## SCHEMATIC DIAGRAM




| THERMAL DATA | | | TO-99 | Minidip | SO-8 |
|---|---|---|---|---|---|
| $R_{th\ j\text{-}amb}$ | Thermal resistance junction-ambient | max | 155 °C/W | 120 °C/W | 200* °C/W |

* Measured with the device mounted on a ceramic substrate (25 x 16 x 0.6 mm)

## ELECTRICAL CHARACTERISTICS (see note)

| Symbol | Parameter | Test conditions | LS 148 Min. | LS 148 Typ. | LS 148 Max. | LS 148A Min. | LS 148A Typ. | LS 148A Max. | LS 148C Min. | LS 148C Typ. | LS 148C Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{os}$ | Input offset voltage | $T_{amb}$= 25°C, $R_g \leqslant 10\ k\Omega$ | | 1 | 5 | | | | | 2 | 6 | mV |
| | | $R_g \leqslant 50\Omega$ | | | | | 0.5 | 2 | | | | mV |
| | | $T_{amb}$= $T_{min}$ to $T_{max}$, $R_g \leqslant 10\ k\Omega$ | | 1 | 6 | | | | | | 7.5 | mV |
| | | $R_g \leqslant 50\Omega$ | | | | | 0.5 | 3 | | | | mV |
| $\Delta V_{os}$ | Input offset voltage adjust. range | $T_{amb}$= 25°C | | ±15 | | | ±25 | | | ±15 | | mV |
| $\frac{\Delta V_{os}}{\Delta T}$ | Average input offset voltage drift | $R_g \leqslant 50\Omega$ | | | | | 2.5 | 15 | | | | $\frac{\mu V}{°C}$ |
| $I_{os}$ | Input offset current | $T_{amb}$= 25°C | | 20 | 200 | | 2 | 10 | | 20 | 200 | nA |
| | | $T_{amb}$= $T_{min}$ to $T_{max}$ | | 50 | 500 | | | 25 | | | 300 | nA |
| $\frac{\Delta I_{os}}{\Delta T}$ | Average input offset current drift | | | | | | | 0.15 | | | | $\frac{nA}{°C}$ |
| $I_b$ | Input bias current | $T_{amb}$= 25°C | | 80 | 500 | | 20 | 75 | | 80 | 500 | nA |
| | | $T_{amb}$= $T_{min}$ to $T_{max}$ | | | 1.5 | | | 0.1 | | | 0.8 | µA |
| $R_i$ | Input resistance | $T_{amb}$= 25°C | 0.3 | 2 | | 2 | 10 | | 0.3 | 2 | | MΩ |
| $V_i$ | Input voltage range | | ±12 | ±13 | | ±12 | ±13 | | ±12 | ±13 | | V |
| $G_v$ | Large signal voltage gain | $T_{amb}$= 25°C, $R_L \geqslant 2\ k\Omega$, $V_s$= ±15V $V_o$= ±10V | 94 | 104 | | 94 | 108 | | 86 | 104 | | dB |
| | | $T_{amb}$= $T_{min}$ to $T_{max}$, $R_L \geqslant 2\ k\Omega$, $V_s$= ±15V $V_o$= ±10V | 88 | | | 88 | | | 84 | | | dB |
| $V_o$ | Output voltage swing | $V_s$= ±15V, $R_L \geqslant 10\ k\Omega$ | ±12 | ±14 | | ±12 | ±14 | | ±12 | ±14 | | V |
| | | $R_L \geqslant 2\ k\Omega$ | ±10 | ±13 | | ±10 | ±13 | | ±10 | ±13 | | V |
| $I_{sc}$ | Output short circuit current | | | 25 | | | 25 | | | 25 | | mA |
| CMR | Common mode rejection | $R_g \leqslant 10\ k\Omega$ $V_{CM}$= ±12V | 70 | 90 | | 80 | 95 | | 70 | 90 | | dB |
| SVR | Supply voltage rejection | $V_s$= ±5 to ± 20V, $R_g \leqslant 10\ k\Omega$ | 76 | 90 | | 80 | 97 | | 76 | 90 | | dB |
| SR | Slew rate | $T_{amb}$= 25°C, $R_L \geqslant 2\ k\Omega$, $G_v$= 1 | | 0.5 | | | 0.5 | | | 0.5 | | V/µs |
| | | $T_{amb}$= 25°C, $R_L \geqslant 2\ k\Omega$, $G_v$= 10* | | 5.5 | | | 5.5 | | | 5.5 | | V/µs |

* $C_C$ = 3.5 pF

## ELECTRICAL CHARACTERISTICS (continued)

| | Parameter | Test conditions | LS 148 Min. | LS 148 Typ. | LS 148 Max. | LS 148A Min. | LS 148A Typ. | LS 148A Max. | LS 148C Min. | LS 148C Typ. | LS 148C Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Transient respon. (unity gain) | $T_{amb}$= 25°C<br>$V_i$= 20 mV  $C_c$= 30 pF<br>$R_L$= 2 kΩ  $C_L \leq$ 100 pF | | | | | | | | | | |
| | Rise time | | | 0.2 | | | 0.2 | | | 0.2 | | μs |
| | Overshoot | | | 5 | | | 5 | | | 5 | | % |
| $I_s$ | Supply current | $T_{amb}$= 25°C | | 1.9 | 2.8 | | 1.9 | 2.8 | | 1.9 | 2.8 | mA |
| $P_S$ | Power consumption | $T_{amb}$= 25°C<br>$V_s$= ±20V | | | | | 60 | 85 | | | | mW |
| | | $V_s$= ±15V | | 60 | 85 | | | | | 60 | 85 | mW |
| | | $V_s$= ±15V<br>$T_{amb}$= $T_{min}$ | | 60 | 100 | | 60 | 100 | | 60 | 100 | mW |
| | | $T_{amb}$= $T_{max}$ | | 45 | 75 | | 40 | 75 | | | | mW |

Note: These specifications, unless otherwise specified, apply for $V_s$= ±15V and $T_{amb}$= -55 to 125°C for LS 148 and LS 148A. For LS 148C these specifications apply for $T_{amb}$= 0 to 70°C ($C_c$= 30 pF).

Fig. 1 - Voltage offset null circuit

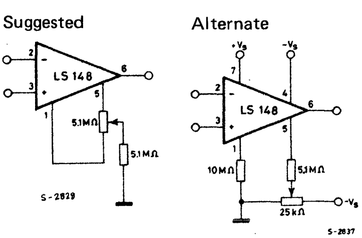
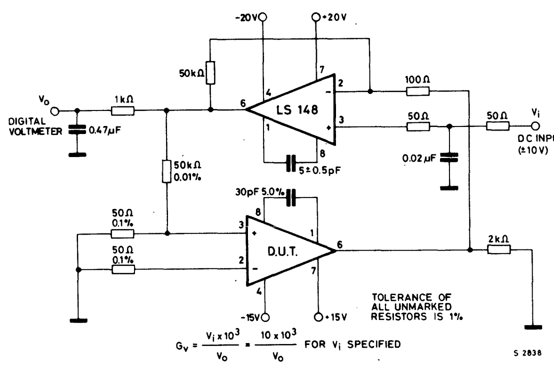



Fig. 2 - Gain test circuit



## Typical performance curves for LS 148

Fig. 3 - Input bias current vs. ambient temperature

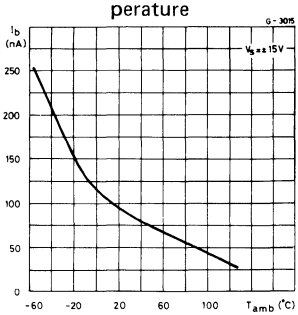



Fig. 4 - Input resistance vs. ambient temperature

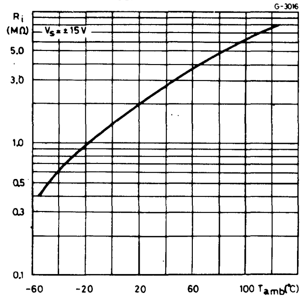



Fig. 5 - Output short-circuit current vs. ambient temperature

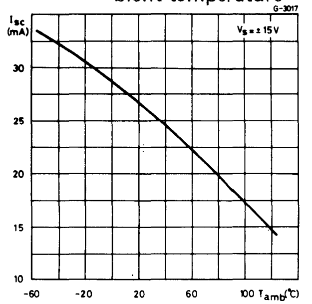



Fig. 6 - Input offset current vs. ambient temperature

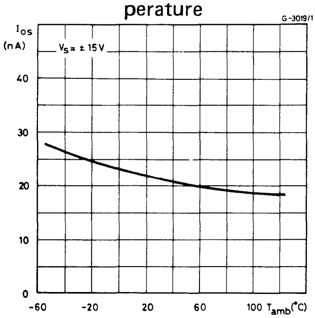



Fig. 7 - Power consumption vs. ambient temperature

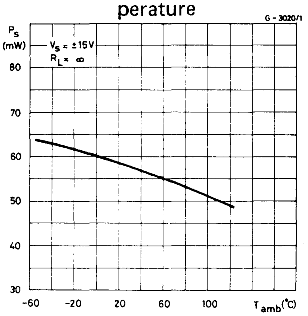
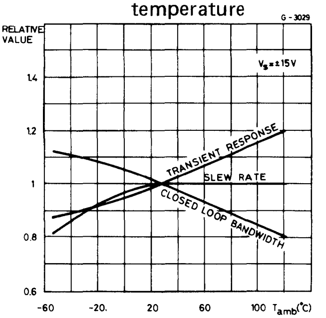



Fig. 8 - Frequency characteristics vs. ambient temperature




## Typical performance curves for LS 148C

Fig. 9 - Input bias current vs. ambient temperature

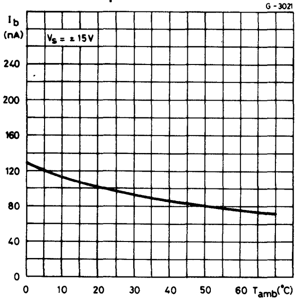



Fig. 10 - Input resistance vs. ambient temperature

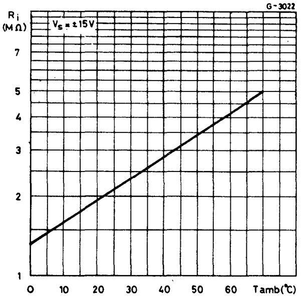



Fig. 11 - Output short-circuit current vs. ambient temperature

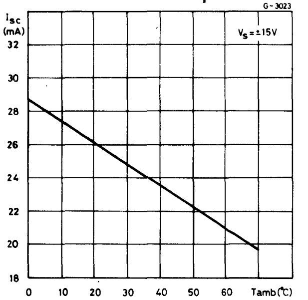


Fig. 12 - Input offset current vs. ambient temperature

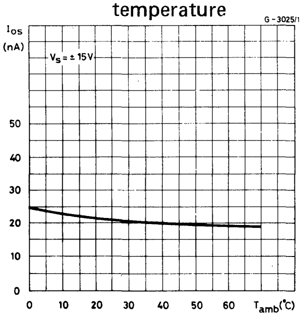



Fig. 13 - Power consumption vs. ambient temperature

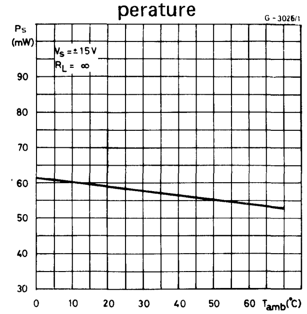
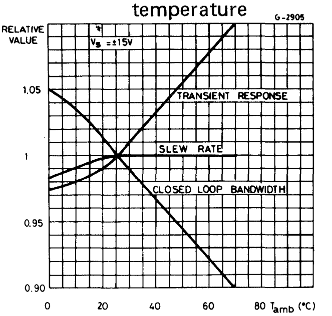



Fig. 14 - Frequency characteristics vs. ambient temperature




## Typical performance curves for LS 148 and LS 148C

Fig. 15 - Open loop voltage gain vs. supply voltage

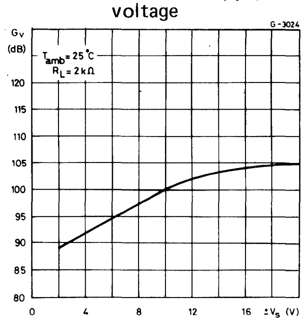



Fig. 16 - Output voltage swing vs. supply voltage

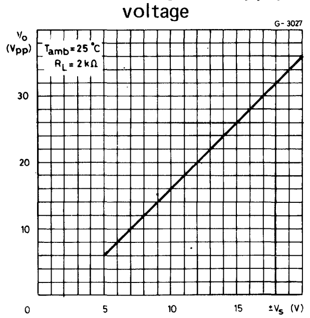



Fig. 17 - Power consumption vs. supply voltage

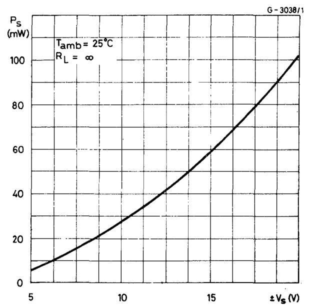



Fig. 18 - Output voltage swing vs. load resistance

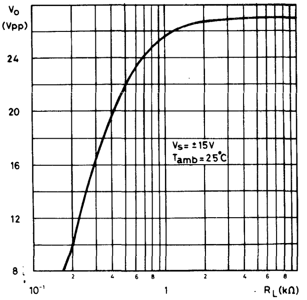



Fig. 19 - Input offset current vs. supply voltage

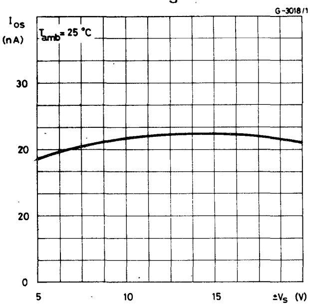



Fig. 20 - Input common mode voltage range vs. supply voltage

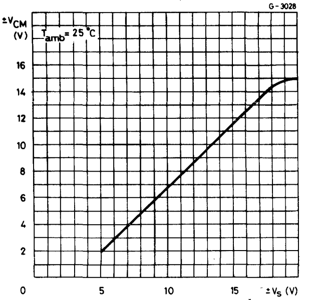


Fig. 21 - Input noise voltage vs. frequency

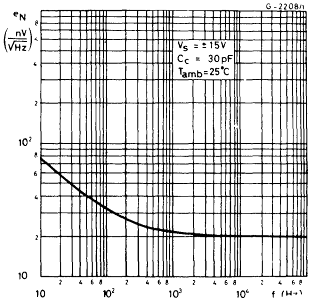



Fig. 22 - Input noise current vs. frequency

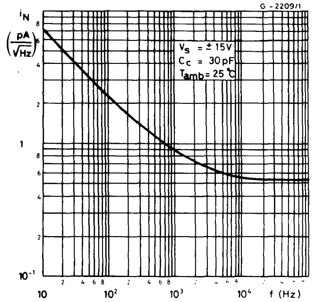



Fig. 23 - Broadband noise for various bandwidths

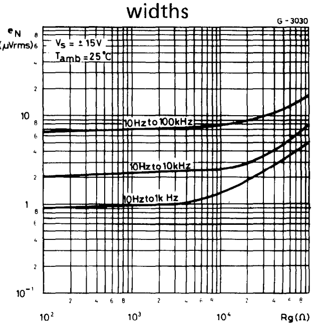



Fig. 24 - Open loop frequency and phase response vs. frequency

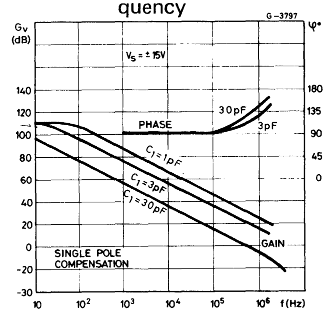



Fig. 25 - Output voltage swing vs. frequency

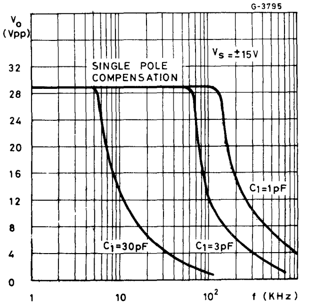



Fig. 26 - Slew-rate

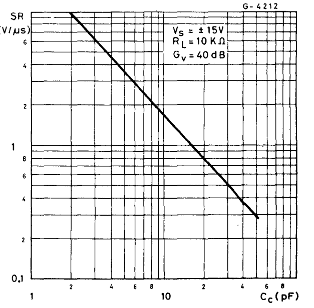



Fig. 27 - Compensation capacitance vs. closed loop voltage gain

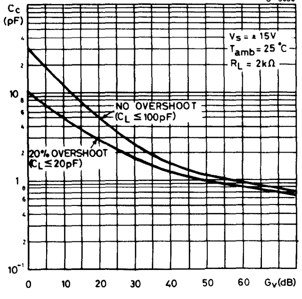



Fig. 28 - Input resistance and input capacitance vs. frequency

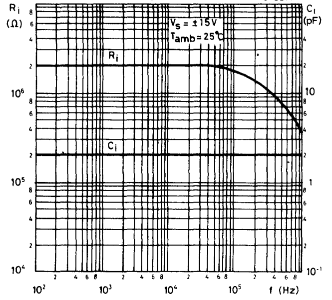
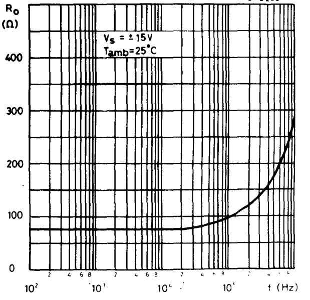



Fig. 29 - Output resistance vs. frequency



**LS148**
**LS148A**
**LS148C**

Fig. 30 - Frequency characteristics vs. supply voltage

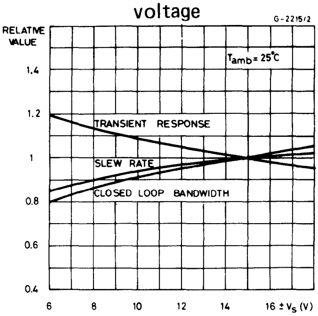



Fig. 31 - Voltage follower transient response (unity gain)

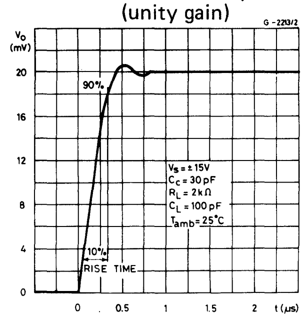



Fig. 32 - Transient response test circuit

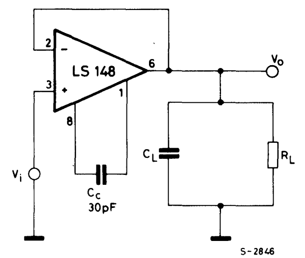



Fig. 33 - Voltage follower large-signal pulse response

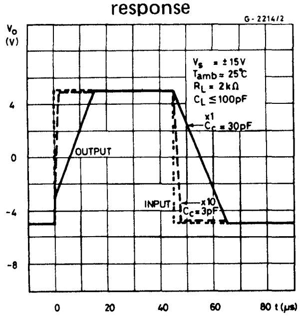



Fig. 34 - Feed forward compensation

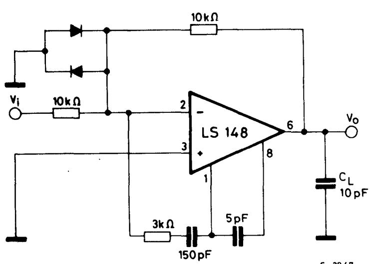
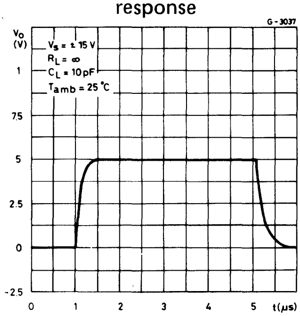
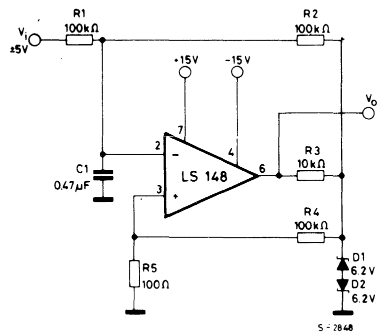



Fig. 35 - Large signal feed forward transient response




## TYPICAL APPLICATIONS

Fig. 36 - Pulse width modulator




$f_c = \frac{1}{2\pi R2\ C1}$

$f_n = \frac{1}{2\pi R1\ C1}$

$= \frac{1}{2\pi R2\ C2}$

$f_c < f_n < f_{unity\ gain}$