



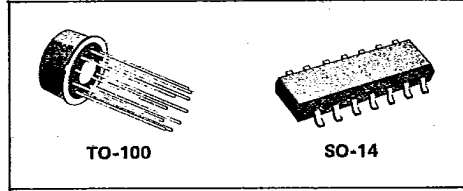
**LS025**

**BALANCED MODULATOR**

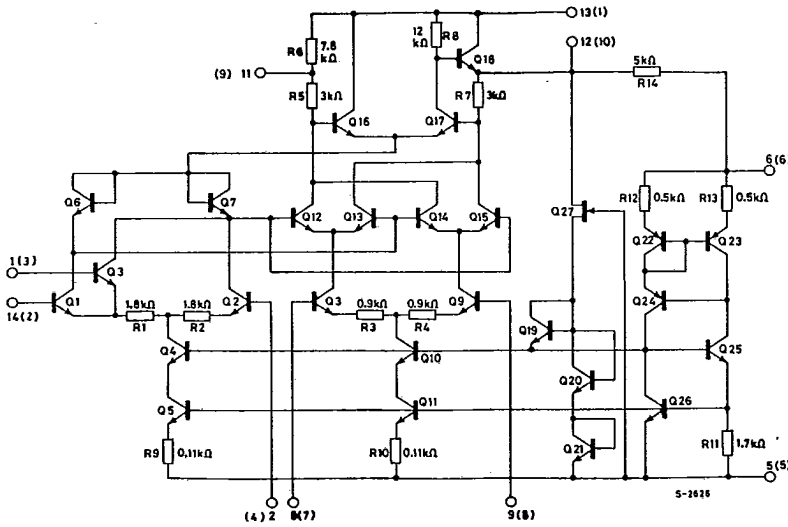
- SINGLE OR DUAL SUPPLY OPERATION
- LOW POWER CONSUMPTION
- LOW CARRIER LEAKAGE
- LOW DISTORTION
- LOW NOISE

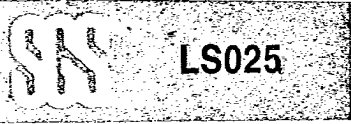
the audio bandwidth. The LS025 is available in TO-100 metal case, while the hermetic gold chip (8000 series) is available in SO-14 (14-lead plastic micropackage). This last version is particularly suitable for professional and telecom applications wherever very high MTBF are required.

The LS025 is a low noise linear integrated circuit, intended for use as a channel modulator and demodulator in FDM telephone equipments and as analogue AC and DC multiplier in industrial and professional applications. It features low quiescent power consumption, low distortion and intermodulation. It shows a typical carrier leakage better than 85dB throughout



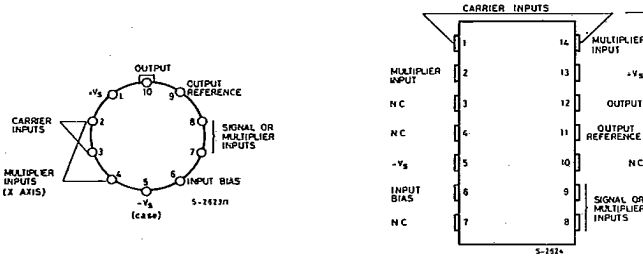
**SCHEMATIC DIAGRAM** (The pin numbers refer to the  $\mu$  package version, while the numbers in brackets refer to the TO-100 version)





| ABSOLUTE MAXIMUM RATINGS |  | TO-100        | $\mu$ package |
|--------------------------|--|---------------|---------------|
| $V_s$                    | Supply voltage                         | 30 V          |               |
| $\Delta V_i$             | Differential input voltage             | $\pm 5$ V     |               |
| $T_{op}$                 | Operating temperature                  | -25 to 85 °C  |               |
| $P_{tot}$                | Power dissipation at $T_{amb} = 70$ °C | 520 mW        | 400 mW        |
| $T_{stg}$                | Storage temperature                    | -65 to 150 °C | -55 to 150 °C |

**CONNECTION DIAGRAMS AND ORDERING NUMBERS**  
 (top views)

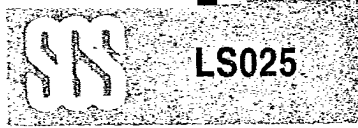


| Type    | TO-100  | SO-14    |
|---------|---------|----------|
| LS 025  | LS 025T | LS025M   |
| LS 8025 |         | LS 8025M |

**THERMAL DATA**

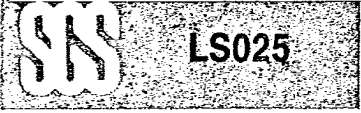
|                |                                     | TO-100 | SO-14     |
|----------------|-------------------------------------|--------|-----------|
| $R_{th j-amb}$ | Thermal resistance junction ambient | max    | 155 °C/W  |
|                |                                     |        | 200* °C/W |

\* The thermal resistance is measured with the device mounted on a ceramic substrate (25 x 16 x 0.6 mm).



**ELECTRICAL CHARACTERISTICS** (Referred to the circuit of fig. 1;  $T_{amb} = 25^{\circ}\text{C}$  unless otherwise specified. The pins correspond to the  $\mu$ package version)

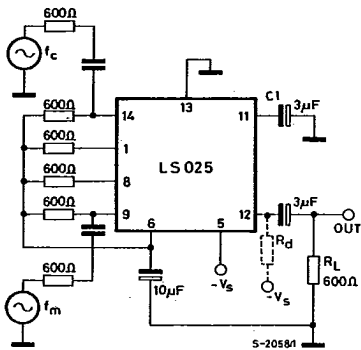
| Parameter    | Test conditions                          | Min.   | Typ. | Max. | Unit             |
|--------------|--|--|------|------|------------------|
| $V_s$        | Supply voltage range                     | -12  |      | -30  | V                |
| $I_s$        | Supply current                           |  | 2    | 2.5  | mA               |
| $I_b$        | Input bias current                       | Pins 14-1  | 0.7  | 2    | $\mu\text{A}$    |
|              |  | Pins 14-2  | 0.7  | 2    | $\mu\text{A}$    |
|              |  | Pins 8-9   | 1.4  | 4    | $\mu\text{A}$    |
| $\Delta I$   | Input offset current                     | Pins 14-1  | 50   |      | nA               |
|              |  | Pins 14-2  | 70   |      | nA               |
|              |  | Pins 8-9   | 100  |      | nA               |
|              | Positive input common mode voltage       |  | 4.5  |      | V                |
|              | Negative input common mode voltage       |  | -8   |      | V                |
| $V_o$        | DC output voltage (pin 12)               | -3.2   | -3.8 | -4.6 | V                |
| $\Delta V_o$ | Differential output voltage (pins 11-12) |  | 25   | 100  | mV               |
| $V_{ref}$    | Input biasing reference voltage (pin 6)  |  | -7.5 |      | V                |
| $R_i$        | Input resistance                         | Pins 14-1  | 30   |      | $\text{k}\Omega$ |
|              |  | Pins 14-2  | 300  |      | $\text{k}\Omega$ |
|              |  | Pins 8-9   | 150  |      | $\text{k}\Omega$ |
| $R_o$        | Output resistance                        | $f = 1 \text{ kHz}$  | 3    | 10   | $\Omega$         |
| $V_o$        | Output voltage swing                     | 1  | 1.3  |      | V <sub>pp</sub>  |
| CMR          | Common mode rejection                    | CM signal (pins 14-1)<br>V = 700 mVrms $f_1 = 10 \text{ kHz}$<br>Diff. signal (pins 8-9)<br>V = 350 mVrms $f_2 = 40 \text{ kHz}$ | 98   |      | dB               |
|              |  | CM signal (pins 14-2)<br>V = 700 mVrms $f_1 = 10 \text{ kHz}$<br>Diff. signal (pins 8-9)<br>V = 350 mVrms $f_2 = 40 \text{ kHz}$ | 86   |      | dB               |
|              |  | CM signal (pins 8-9)<br>V = 350 mVrms $f_1 = 10 \text{ kHz}$<br>Diff. signal (pins 14-1)<br>V = 175 mVrms $f_2 = 40 \text{ kHz}$ | 80   |      | dB               |
| SVR          | Positive supply voltage rejection        | $f = 1 \text{ kHz}$  | 33   |      | dB               |
| SVR          | Negative supply voltage rejection        |  | 80   |      | dB               |



**ELECTRICAL CHARACTERISTICS** (continued)

| Parameter                                 | Test conditions                        | Min.   | Typ. | Max.  | Unit            |     |
|---|--|--|------|-------|-----------------|-----|
| K   | Scale factor                           |  | 3.2  |       | V <sup>-1</sup> |     |
| G <sub>c</sub>                            | Conversion gain                        | 4.5  | 5    | 5.5   | dB              |     |
| ΔG <sub>c</sub>                           | Conversion gain change                 | T <sub>amb</sub> = 10 to 50°C                  |      | ± 0.1 | dB              |     |
|   | Carrier leakage                        | V <sub>m</sub> = 0                             |      | -35   | -50             | dBv |
| $\frac{V_{f_m}}{V(f_c \pm f_m)}$          | Modulating signal leakage              | -35  | -50  |       | dBmo            |     |
| $\frac{V(2f_m)}{V(f_c \pm f_m)}$          | 2nd harmonic modulating signal leakage |  | -75  |       | dBmo            |     |
| $\frac{V(f_c \pm 2f_m)}{V(f_c \pm f_m)}$  | 2nd harmonic distortion                | -60  | -75  |       | dBmo            |     |
| $\frac{V_2(f_c \pm f_m)}{V(f_c \pm f_m)}$ | 2nd harmonic distortion                | -55  | -80  |       | dBmo            |     |
| $\frac{V(f_c \pm 3f_m)}{V(f_c \pm f_m)}$  | 3rd harmonic distortion                | -60  | -79  |       | dBmo            |     |
|   | Low frequency thermal noise            | V <sub>m</sub> = 0<br>B = 100 Hz<br>f = 1 kHz  |      | -115  | -125            | dBv |
|   | High frequency thermal noise           | V <sub>m</sub> = 0<br>B = 100 Hz<br>f = 30 kHz |      |       | -127            | dBv |

Fig. 1 - Test and application circuit of modulator with single supply voltage



**Working conditions**  
 V<sub>s</sub> = -20V  
 f<sub>c</sub> = 130 kHz  
 f<sub>m</sub> = 25 kHz  
 V<sub>o</sub> = -15 dBv (f<sub>c</sub> ± f<sub>m</sub>)  
 V<sub>c</sub> = -13 dBv  
 R<sub>L</sub> ≡ 600 Ω

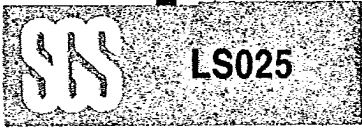


Fig. 2 - Carrier leakage vs. modulation signal input offset

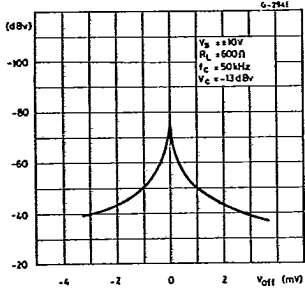


Fig. 3 - Conversion gain vs. frequency

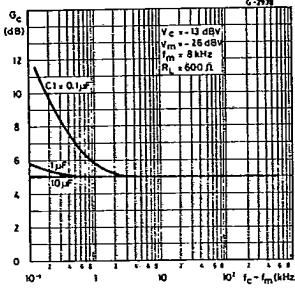


Fig. 4 - Distortion vs. output level

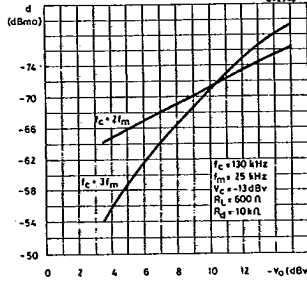


Fig. 5 - Carrier leakage adjustment circuit for system with two supply voltages

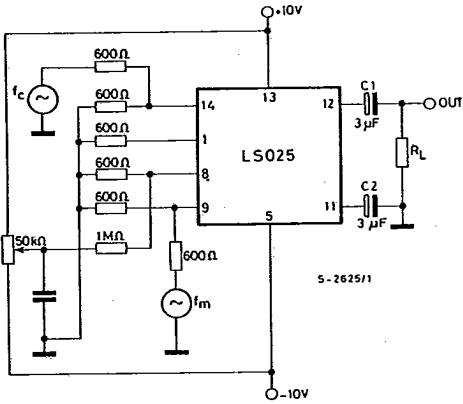
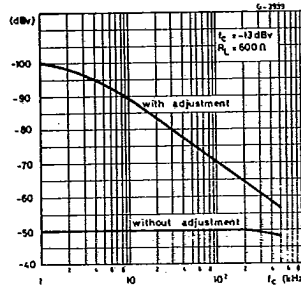


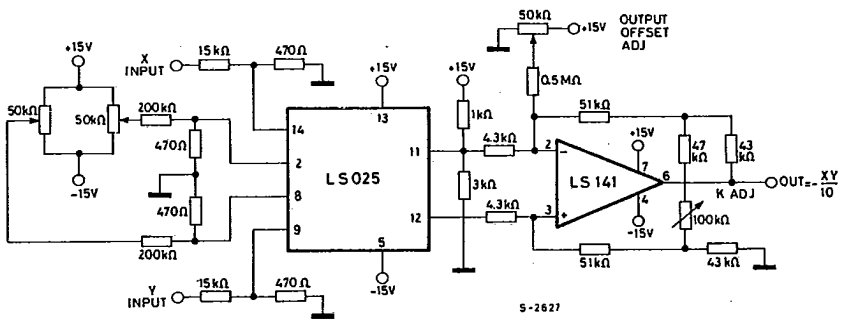
Fig. 6 - Carrier leakage vs. frequency





APPLICATION INFORMATION

Fig. 7 - DC multiplier



Application diagram of DC multiplier, have a scale factor  $K = 0.1$ . Typical linearity and leakage errors are less than 1%.  
 The input voltage range is  $\pm 10V$ .

Definition of units

- dBm** : power level ( $10 \lg \frac{P_2}{P_1}$ ) is expressed in dBm when  $P_1$  is 1 mW, therefore 0 dBm = 1 mW.
- dBmo** : the power is expressed in dBmo when referred to an established power level in the circuit, generally the output signal level.  
 e.g.: if the output level is -15 dBm and this level is chosen as reference, then 0 dBmo = -15 dBm; if another signal, i.e. the distortion measured at the same point of the circuit, is -90 dBm, then the distortion is -75 dBmo.
- dBv** :  $20 \lg \frac{V_2}{V_1}$  when  $V_1 = 775 \text{ mVrms}$ .

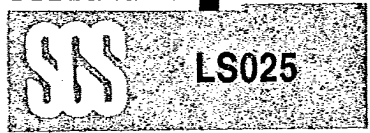
Definition of terms

Common mode rejection ratio :  $CMR = 20 \lg \frac{V_{CM} G}{V_o}$

with  $G$  = Conversion gain with specified circuit conditions  
 $V_{CM}$  = Common mode signal level  
 $V_o$  = Output signal level at frequency =  $f_2 \pm f_1$

Scale factor :  $K = \frac{V_o}{V_x \cdot V_y}$

with  $V_x$  = voltage input (pins 14 - 2)  
 $V_y$  = voltage input (pins 8 - 9)



APPLICATION INFORMATION (continued)

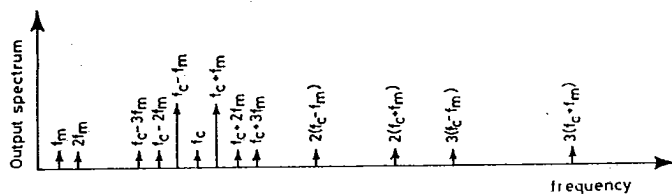
Conversion gain :  $G_c = 20 \lg \frac{V_o(f_c \pm f_m)}{V_i(f_m)}$

Carrier leakage : is defined as the output voltage at carrier frequency with only the carrier applied to the input (modulating voltage = 0)

Modulating signal leakage: is defined as the output voltage, at modulating frequency, referred to fundamental carrier sidebands

M.S.L. =  $20 \lg \frac{V_o(f_m)}{V_o(f_c \pm f_m)}$

Output spectrum vs. frequency



- $f_c$  = carrier fundamental (leakage)
- $f_m$  = mod. sig. (leakage)
- $nf_m$  = harmonic modulating signal (leakage)
- $f_c \pm f_m$  = fundamental carrier sidebands
- $f_c \pm nf_m$  = fundamental carrier sideband harmonics
- $n(f_c \pm f_m)$  = carrier harmonic sidebands