# STEREO MODULATOR

## ■ GENERAL DESCRIPTION

The NJM2035 is an integrated circuit used to generate a stereo composite signal and obtain switching output and 19kHz pilot signal due to two input audio signal and 38kHz X-tal and a few external CR.

The NJM2035 operates at 1.5V battery typically and even at 1.2V obtains separation more than 25dB.

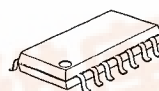NJM2035 can generate stereo multiplex signal easily by combination battery generator section.

## ■ FEATURES

- Low Operating Voltage        $(V^+ \geqq 1.0V)$
- Low Operating Current        $(Icc \leqq 3.0mA)$
- High Separation              $(SEP \geqq 25dB)$
- Separation Adjustable
- Package Outline              DIP14, DMP14
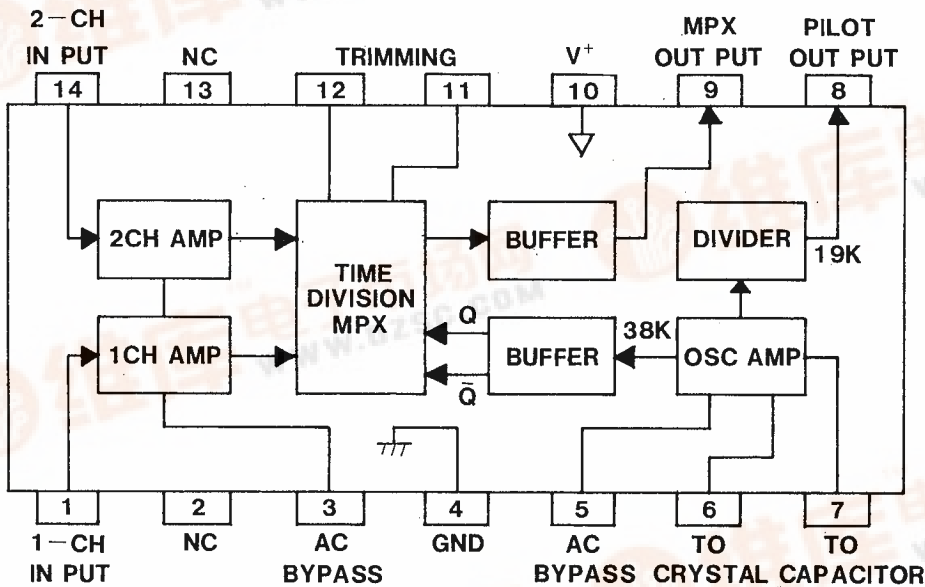- Bipolar Technology

## ■ PACKAGE OUTLINE
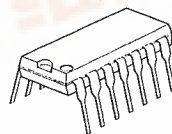
NJM2035D

NJM2035M

## ■ BLOCK DIAGRAM



NJM2035D
NJM2035M

■ **ABSOLUTE MAXIMUM RATINGS** (Ta=25℃)

| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| Supply Voltage | $V^+$ | 3.6 | V |
| Power Dissipation | $P_D$ | (DIP14)   500<br>(DMP14)  300 | mW |
| Operating Temperature Range | $T_{opr}$ | $-20 \sim +75$ | ℃ |
| Storage Temperature Range | $T_{stg}$ | $-40 \sim +125$ | ℃ |

■ **ELECTRICAL CHARACTERISTICS** (Ta=25℃, $V^+$=1.5V)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Operating Cuurent | $I_{CC}$ | $R_L = \infty$ | — | 1.8 | 3.0 | mA |
| Input Impendance | $Z_{IN}$ | f=1kHz | — | 420 | — | Ω |
| Maximum Input Current | $I_{IM}$ | | — | 4.1 | — | μA |
| Voltage Gain | $G_V$ | $R_S = 2k\Omega$, $R_L = 10k\Omega$ | 16 | 20 | — | dB |
| Difference Gain Between Channels | $G_{VD}$ | $R_S = 2k\Omega$, $R_L = 10k\Omega$ | — | — | 2.0 | dB |
| Equivalent Input Noise Voltage | $V_{NI}$ | $R_S = 2k\Omega$, $R_L = 10k\Omega$, Aweighted | — | — | 2.0 | μVrms |
| Maximum Output Voltage Swing | $V_{OM}$ | $R_S = 2k\Omega$, $R_L = 10k\Omega$ | 140 | 200 | — | mVp-p |
| Output Impendance | $Z_O$ | f=1kHz | — | 230 | — | Ω |
| Pilot Output Voltage | $V_{OP}$ | $R_L = 150k\Omega$ | — | 240 | — | mV |
| Pilot Output Impendance | $R_{OP}$ | | — | 3 | — | kΩ |
| Separation | SEP | f=1kHz at Application Circuit | — | 40 | — | dB |
| Internal Separation Compensation | S.C | | — | $-19$ | — | dB |

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# NJM2035

■ **TYPICAL CHARACTERISTICS (＊：BY APPLICATION CIRCUIT)**

### Operating Current vs. Operating Voltage

($R_L = \infty$, Ta = 25℃)

Operating Current
Icc
(mA)

Operating Voltage V⁺ (V)
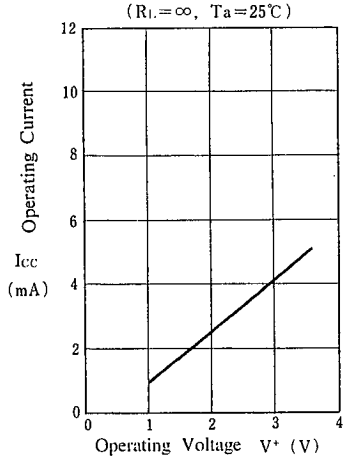
### Voltage Gain vs. Input Series Resistance

(f = 1kHz, $R_L$ = 10kΩ, Ta = 25℃)

Voltage Gain
Gv
(dB)

Input Series Resistance Rs (Ω)
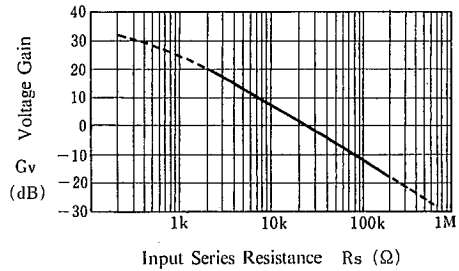
### Pilot Output Voltage vs. Operating Voltage

($R_L$ = 150kΩ)

Pilot Output Voltage
Vop
(mV)

Ta = −20℃
Ta = ±0℃
Ta = +25℃
Ta = +50℃
Ta = +75℃

Operating Voltage V⁺ (V)
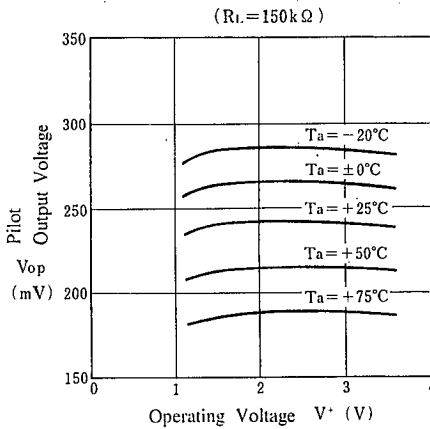
### ※ Separation vs. Frequency

($V_{IN}$ = 150mV, Ta = 25℃)

Separation
SEP
(dB)

V' = 1.2(V)
V' = 1.5(V)       V' = 1.8(V)

Frequency f (Hz)
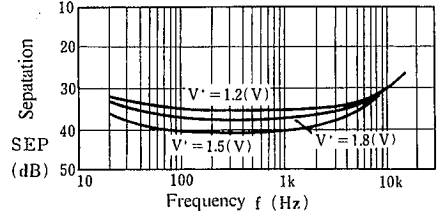
### ※ Total Harmonic Distortion vs. Modulation

(f = 1kHz, Ta = 25℃)

Total Harmonic Distortion
THD
(%)

V' = 1.2V
V' = 1.5V
V' = 1.8V

Modulation Mod (%)
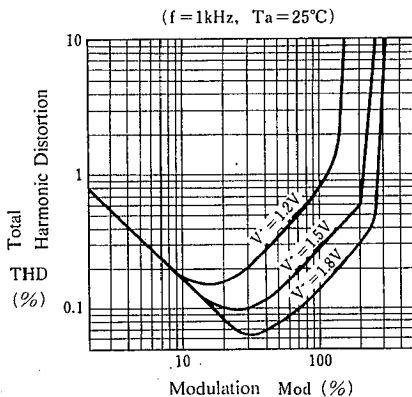
### MPX Maximum Output Voltage Swing vs. Operating Voltage

(f = 1kHz, $R_L$ = 10kΩ)

MPX Maximum Output Voltage Swing
Vₒₘ
(mVp-p)

Ta = −20℃
Ta = 25℃
Ta = 75℃

Operating Voltage V⁺ (V)
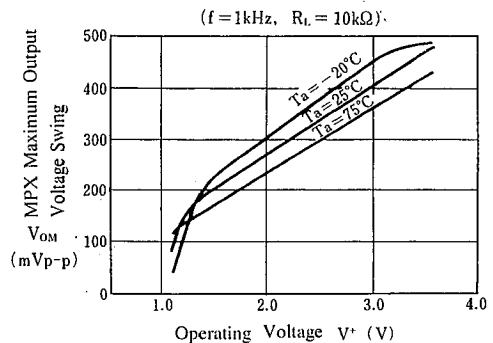
## ■ APPLICATION CIRCUIT EXAMPLES

The following block diagram shows an FM stereo transmitter using NJM2035. Input a current mode signal, because two inputs of NJM2035 are of a low impedance type. Also, the pre-emphasis can be applied at a time constant of $C_L$ and $R_1$ by utilizing this characteristic.

Input series resistance Rs of low band can be obtained from the maximum input voltage $V_{IM(P-P)}$ and the maximum input current $I_{IM}$ of NJM2035.

$$Rs = V_{IM}/2I_{IM} \quad (Rs = R_1 + R_2)$$

However, the circuit for stabilized operation, $R_2$ must stay between $2 \sim 12k\Omega$, and also, in order to get enough pre-emphasis characteristics, $R_1$ is repuired to maintain within the range of $5 \times R_2 \sim 10 \times R_2$. Transmitting on FM stereo. it is advisable to set the pre-emphasis time $C_1$, $R_1$ at $50\mu s$. When it is large maximum input voltage and could not satisfy $R_1$, $R_2$ condition, it is important to attenuate the input voltage beforehand, like that of Fig.2 the circuit example. In this case however, special care must be taken for not making the pre-emphasis time control influenced from the attennuter.

In order to get the important composit signals for stereo transmitting, the MPX signal and the pilot signal which were delivered output at each different pins, to be mixed (MIX) and the ratio is decided by the modulation of NJM2035 the maximum output voltage Vom that means that, it can be decided by how much percent to be set the ratio of the maximum modulation. The maximum modulation takes the essential part to decide the dynamic range and to be set with consideration of modulation sensitivity of FM transmitter, S/N and also with the linearity of receiver. In general, 200% modulation ( $\Delta f = \pm 150MHz$ ) will give the satisfacting result.
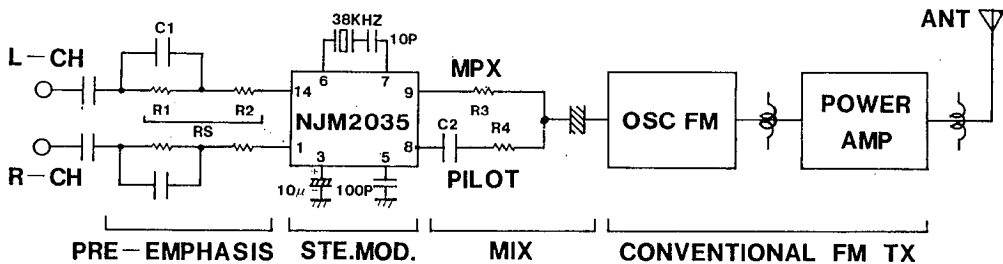


Fig1

## ■ RECOMMENDED APPLICATION CIRCUIT & EACH WAVEFORM



INPUT L-CH   MPX OUT   MPX OUTTHROUGH LPF   MPX OUT WITH PILOT
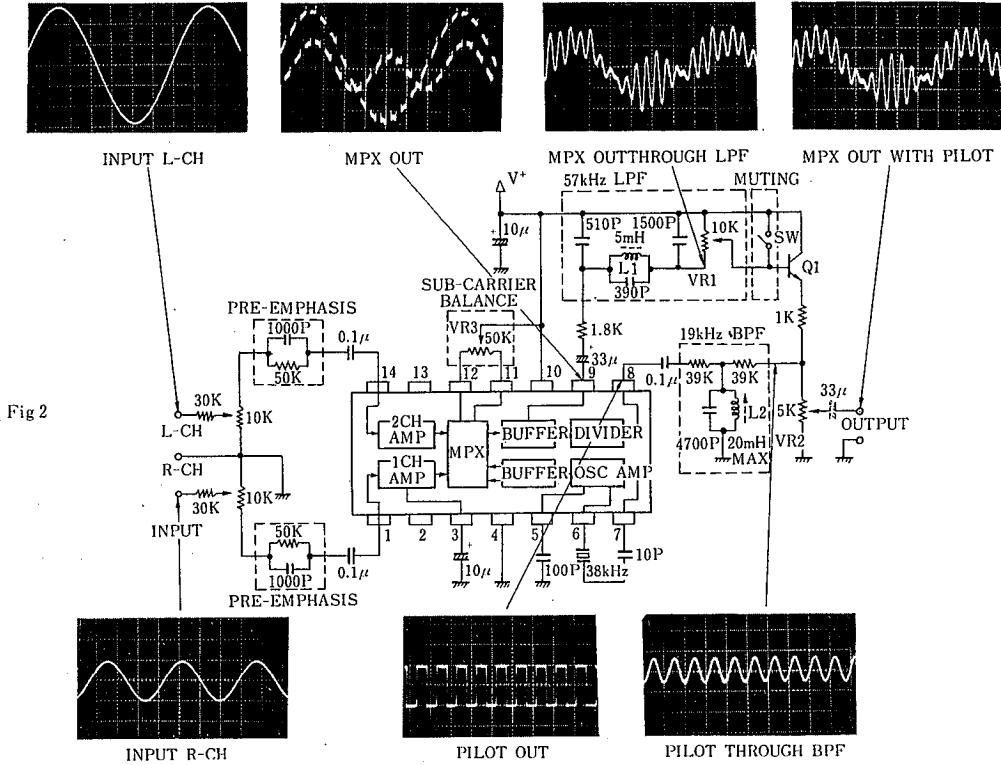
Fig 2



INPUT R-CH   PILOT OUT   PILOT THROUGH BPF

## ■ The adjustment proceduce in the recommended application circuit.

① Sub-carrier leakage can be minimized by the adjustment of $V_{R3}$.

② The maximum output voltage of pilot can be obtained by the adjustment of $L_2$

③ $V_{R2}$ adjustment of the pilot will help to bring the modulation ratio a little over 10% ($\triangle f = \pm 7.5 kHz$)

④ The modulation ratio can be increased as much as 30% at $V_{R1}$ by putting designed standard input.

⑤ By putting only the input for L-channel, and making re-adjustment of $L_2$, so that the maximum power of output at L-cannel can be obtained at the receiver's side. (19kHz phase adjustment)

Against 100% modulation at the recommended circuit S/N at A curve +15kHz LPF 77dB, ane at 15kHz LPF 67dB approximately can be obtained.

Recommended Appkication Circuit & Each Waveform on the other hand, the pilot level is to be modulated 10% with no connection of Max. modulation ratio, so that the following relation can be set.

$$\frac{R_0 + R_3}{R_{0P} + R_4} \times \frac{2\sqrt{2} \, V_{0P}}{V_{0M}} = \frac{10}{200}.$$

Howerer, for the stability in operation, it is advisable to control MPX signal loading more than 1.8kΩ, and the pilot signal loading more than 39kΩ.

As in example of Fig.1 Simplified Application Circuit, when making the rectangular wave like output to be the composit signal itself, the separating effect shall be reduced due to influence by harmonic components included in MPX signal, so that it requires to make the adjustment to be able to get ample separation of pilot signal phase by the operation of $C_2$, $R_4$, time signal. In this procedure, there is defective side of getting slightly difference of the best position of separating effect depending upon the tunner of receiver's side, however, when $R_3 = 2k\Omega$, $R_4 = 150k\Omega$, $C_2 = 330pF$ then the ample separation can be obtained practically.

Special care must be taken that the pilot signal's the third harmonic wave 57kHz will be the cause of dangerous beating.

Fig 2 idicates the example of recommende application circuit of stereo modulaton when NJM2035 in used. As explained in the wave form, high quality composit signal can be obtained by only putting a simpl filter beforehand. Then the previousely mentioned problems can be improved a great deal.

The input in mondulated 30% at AUX level (150mV) ——— changeable of + 3dB~—∞ by volume control.

$V_{R1}$ corresponds to the fluctuation of GV feature of NJM2035, and also for fluctuation of modulation sensitivity of FM modulation circuit which in connected after $V_{R2}$.

$V_{R3}$ is to make minimum adjustment of 38kHz sub-carrier leakage, and with this adjustment, it can control until about −50dB in comparing to 100% modulation level.

# NJM2035

MEMO