Fine Tune Sensitivity 2-wired Monaural Microphone Amplifier with Regulator for Microphone Capsule

■ FEATURES

- Operating Voltage Range V_{DD} = 2.7V to 16V
- 2-wired connections
- Built-in Regulator for Microphone Capsule 1.6V typ.
- Voltage Gain Range
  24dB to 40dB (Set by external resistors.)
- Adjust and memorize the gain by Single-wire serial interface
- Gain Adjustment 9dB ±3dB/0.2dB step
- Maximum Output Voltage 1.5Vrms min.
- Equivalent Input Noise Voltage −112dBV typ.
- CMOS Technology
- Package MSOP10 (TVSP10)

■ DESCRIPTION

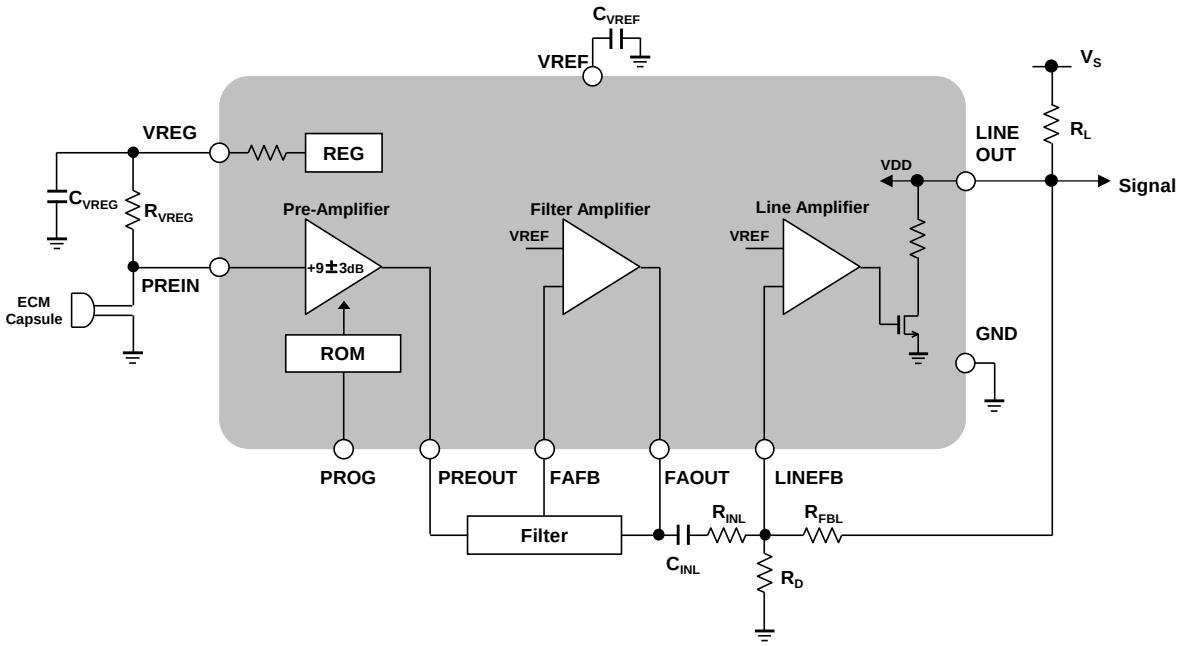
The NJU72097 is a monaural microphone amplifier IC including regulator for microphone capsule, gain adjustor, filter amplifier and line amplifier. It is able to set the output gain by external resistors. And it is able to adjust and memorize the gain after parts assembling.

The NJU72097 is the most suitable for the microphone module which required accurate sensitivity such as ECM and MEMS microphone.

■ APPLICATIONS

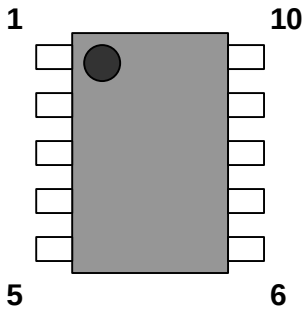
- Microphone module
- Hands-free microphones

■ BLOCK DIAGRAM



■ PIN CONFIGURATION

MSOP10 (TVSP10)



PIN NO.	NAME	FUNCTION
1	PREOUT	Pre-amplifier output terminal
2	FAFB	Filter amplifier feedback terminal
3	FAOUT	Filter amplifier output terminal
4	LINEFB	Line amplifier feedback terminal
5	LINEOUT	Line amplifier output terminal
6	GND	Ground terminal
7	VREF	Reference voltage terminal
8	PROG	Serial clock input terminal
9	VREG	Regulator output terminal for microphone capsule
10	PREIN	Pre-amplifier input terminal

■ PRODUCT NAME INFORMATION

■ ORDERING INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	TERMINAL FINISH	MARKING	WEIGHT (mg)	MOQ (pcs)
NJU72097RB2 (TE1)	MSOP10 (TVSP10)	Yes	Yes	Sn2Bi	72097	19	2000

■ ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATING	UNIT
Operating Voltage	V_{DD}	18(1)	V
Maxim Input Voltage	Vimax	3.3 (2)	V
Power Dissipation (T_a = 25°C) MSOP10 (TVSP10)	P_D	2-Layer 470 (3)	mW
Storage Temperature	T_{stg}	−40 to 150	°C
Junction Temperature	T_j	150	°C

(1) LINEOUT terminal.
(2) FAFB, LINEFB, PREIN terminals.
(3) 2-Layer: Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4).

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	RATING	UNIT
Operating Voltage	V_{DD}	2.7 to 16(1)	V
Operating Temperature	T_{opr}	−40 to 105	°C

(1) LINEOUT terminal.

■ ELECTRICAL CHARACTERISTICS

(V_S = 8V, R_L = 680Ω, R_{INF} = R_{INL} = 6.2kΩ, R_{FBF} = 6.2kΩ, R_{FBL} = 180kΩ, R_D = 27kΩ, f = 1kHz, T_a = 25°C unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC CHARACTERISTICS (Rg = 0Ω, No signal, unless otherwise noted.)						
Supply Current1	I_{DD1}		4.2	4.8	5.4	mA
Supply Current2	I_{DD2}	V_S = 4.7V, VREG = No load, LINEFB = 0V	-	280	-	μA
Supply Current3	I_{DD3}	R_L = 0Ω	-	24	32	mA
Reference Voltage	V_{REF}	FAFB, LINEFB terminals	-	614	-	mV
Output DC Voltage	V_{OUT}	LINEOUT terminal	-	4.7	-	V
AMPLIFIER CHARACTERISTICS (PREIN to LINEOUT, unless otherwise noted.)						
PREIN Input Resistance	Ri_{PRE}		-	15	-	MΩ
Pre-Amplifier TYP Voltage Gain	Gvtyp	V_{IN} = 10mVrms, GAIN setting = 0 × 00	-	9	-	dB
Pre-Amplifier MAX Voltage Gain	Gvmax	V_{IN} = 10mVrms, GAIN setting = 0 × 0F	-	12	-	dB
Pre-Amplifier MIN Voltage Gain	Gvmin	V_{IN} = 10mVrms, GAIN setting = 0 × 10	-	5.8	-	dB
Filter-Amplifier Open loop Voltage Gain	A_{VFA}	R_{LFA} = 2kΩ(1)	-	75	-	dB
Filter-Amplifier Gain Bandwidth Product	GBP_{FA}	R_{LFA} = 2kΩ(1)	-	1	-	MHz
Filter-Amplifier Phase Margin	ϕ_{FA}	R_{LFA} = 2kΩ(1)	-	75	-	deg
Voltage Gain	G_V	V_{IN} = 10mVrms	37.3	38.3	39.3	dB
Frequency Response	ΔG_f	f = 1kHz to 10kHz	−0.5	0.0	0.5	dB
Equivalent Input Noise Voltage	V_{NI}	Weighted-A	-	−112	-	dBV
Total Harmonic Distortion	THD	V_{IN} = 10mVrms, BW = 400Hz to 30kHz	-	0.1	0.5	%
Maximum Output Voltage	V_{OM}	THD = 3%, I_{VREG} = 300μA	1.5	-	-	Vrms
Ripple Rejection	RR	V_{RIPPLE} = 0.5Vrms	25	30	-	dB
REGULATOR CHARACTERISTICS (No signal, unless otherwise noted.)						
Output Voltage	V_{VREG}	No load	-	1.6	-	V
Output Current	I_{VREG}		-	300	500	μA
Filter Resistance	R_{FILTER}		0.8	1.1	1.4	kΩ

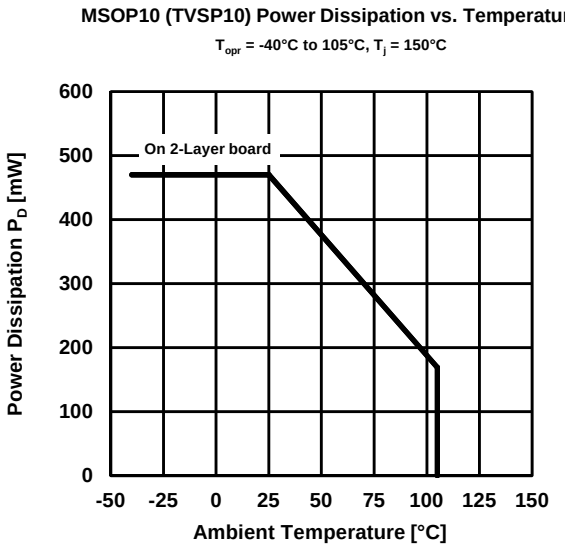
(1) Total load of the Filter-Amplifier

■ THERMAL CHARACTERISTICS

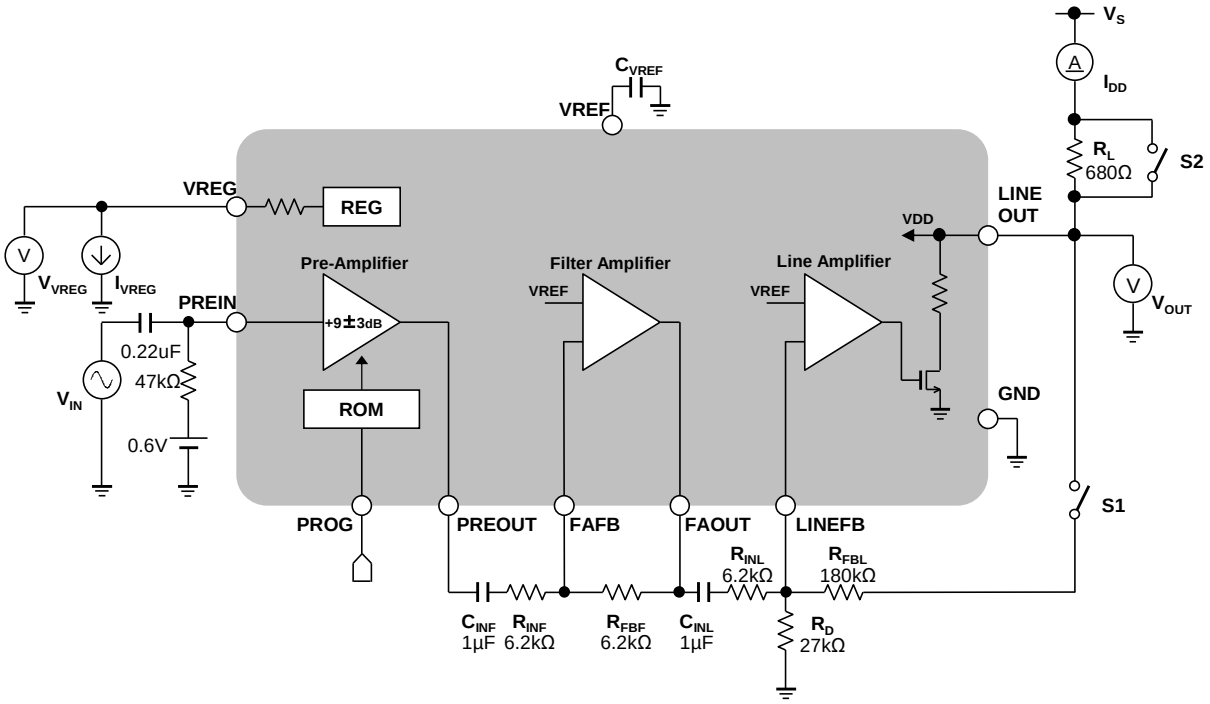
PACKAGE	SYMBOL	VALUE	UNIT
Junction-to-Ambient Thermal Resistance MSOP10 (TVSP10)	θ_{ja}	2-Layer 266 (1)	°C/W

(1) 2-Layer: Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4).

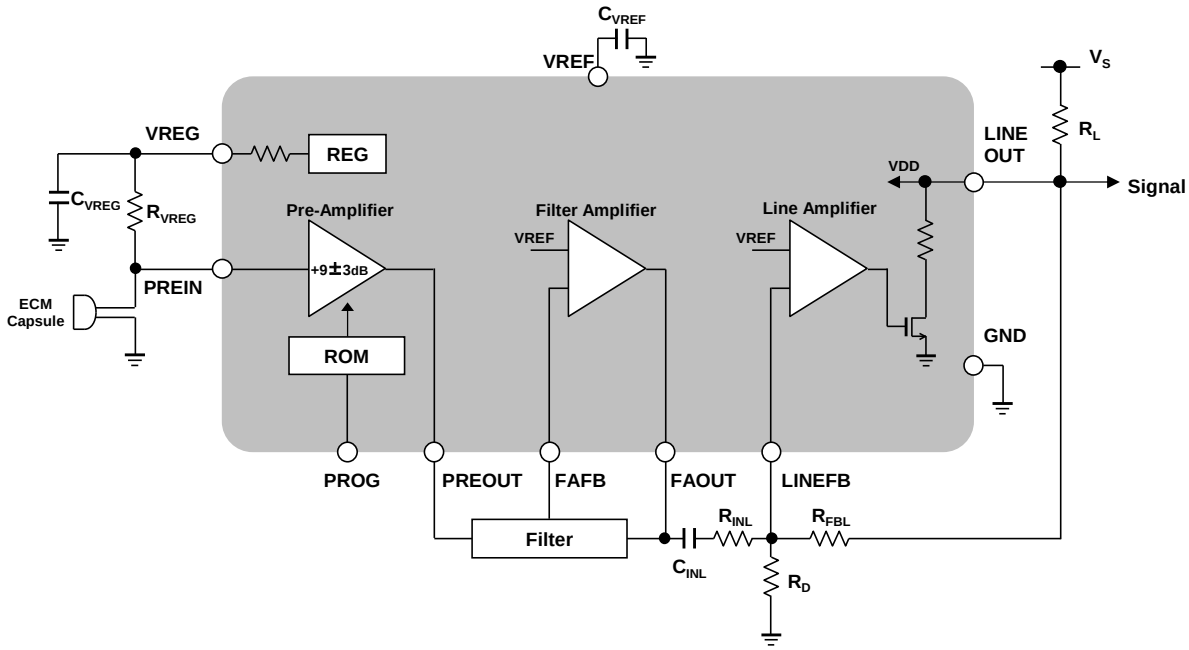
■ POWER DISSIPATION vs. AMBIENT TEMPERATURE



■ TEST CIRCUIT



■ APPLICATION CIRCUIT

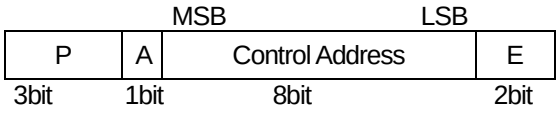


■ DEFINITION OF SERIAL REGISTER

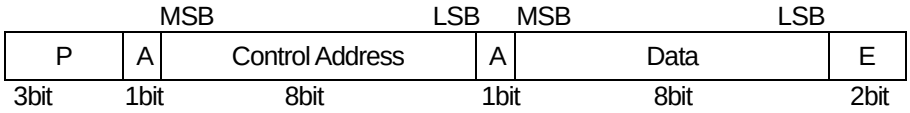
Note) Please don't send except specified data for avoiding an incorrect operation.

SERIAL BUS FORMAT

1byte command



2byte command



P: Preamble
A: Acknowledge Bit (ACK)
E: End Mark

Control Address

Mode	Control Address								Hex	Contents
	MSB							LSB		
RESET	1	0	0	0	0	0	0	0	80(h)	Reload the setting from ROM.
READ	1	0	0	0	0	0	0	1	81(h)	Output the setting to PROG terminal.
TEST	1	0	0	0	0	0	1	0	82(h)	Write the setting on RAM and read it.
WRITE	1	0	0	0	0	1	0	0	84(h)	Write the setting on ROM.

CONTROL REGISTER DATA TABLE

<RESET Mode>

The Data of SERIAL BUS FORMAT is not required. Use the 1byte command format.

<READ Mode>

MSB							LSB
Data							
D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	Setting Data				

<TEST and WRITE Mode>

MSB							LSB
Data							
D7	D6	D5	D4	D3	D2	D1	D0
Don't Care	Don't Care	Don't Care	GAIN				

CONTROL REGISTER DEFAULT VALUE OF INTERNAL ROM

The NJU72097 read setting from internal ROM when power is turn on.
Control register default value of internal ROM is all "0" before you write setting on ROM.

MSB							LSB
Data							
D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0

■ DEFINITION OF RESISTOR

The gain is controlled 5.8dB to 12.0dB in 0.2dB/step by 5-bit signed binary.

MSB LSB

Data							
D7	D6	D5	D4	D3	D2	D1	D0
Don't Care	Don't Care	Don't Care	GAIN				

<GAIN Data>

Data					Setting
D4	D3	D2	D1	D0	
1	0	0	0	0	+5.8dB
1	0	0	0	1	+6.0dB
1	0	0	1	0	+6.2dB
1	0	0	1	1	+6.4dB
1	0	1	0	0	+6.6dB
1	0	1	0	1	+6.8dB
1	0	1	1	0	+7.0dB
1	0	1	1	1	+7.2dB
1	1	0	0	0	+7.4dB
1	1	0	0	1	+7.6dB
1	1	0	1	0	+7.8dB
1	1	0	1	1	+8.0dB
1	1	1	0	0	+8.2dB
1	1	1	0	1	+8.4dB
1	1	1	1	0	+8.6dB
1	1	1	1	1	+8.8dB
0	0	0	0	0	+9.0dB (1)
0	0	0	0	1	+9.2dB
0	0	0	1	0	+9.4dB
0	0	0	1	1	+9.6dB
0	0	1	0	0	+9.8dB
0	0	1	0	1	+10.0dB
0	0	1	1	0	+10.2dB
0	0	1	1	1	+10.4dB
0	1	0	0	0	+10.6dB
0	1	0	0	1	+10.8dB
0	1	0	1	0	+11.0dB
0	1	0	1	1	+11.2dB
0	1	1	0	0	+11.4dB
0	1	1	0	1	+11.6dB
0	1	1	1	0	+11.8dB
0	1	1	1	1	+12.0dB

(1) Initial Setting

■ Serial bus (PROG) control

The NJU72097 has a single-wire serial interface with a PROG terminal which is three-state control of H (High Level), M (Middle Level), and L (Low Level), and data logical values are assigned to H and M as shown in Table 1.

Table1. Control logic table of PROG terminal

Control signal of PROG terminal		Assigned logical value
State	Voltage value	
H	Vprog [V]	1
M	1/2 Vprog[V]	0
L	0[V]	-

An example of writing circuit

Figure 1 is an example of a write circuit using a 3-state buffer consisting of Tr1 and Tr2. Table 2 is a truth table in which the PROG terminal is controlled in 3 states by CLK and DAT signals by this buffer. The buffer also supplies OTP write current from Tr1 and generates M level by R_{PULLUP_DATA} and $R_{PULLDOWN\_DATA}$ when the buffer is Hi-Z.

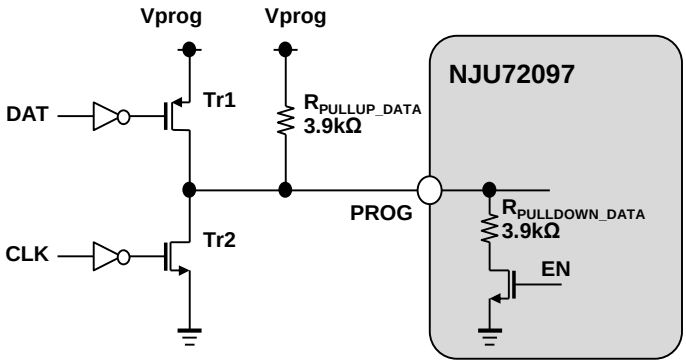


Fig1. An example of writing circuit

Table 2. A truth table of an example of writing circuit.

input data		Control data	
CLK	DAT	PROG terminal	Assigned logical value
H	H	H: Vprog [V]	1
H	L	M: 1/2Vprog [V]	0
L	H	Prohibit	-
L	L	L: Vprog [V]	-

■ TIMING ON SERIAL BUS (PROG)

The NJU72097 adopts the single-wire serial interface by PROG terminal. The serial data is structured by Preamble, Acknowledge (ACK), Control Address, Data and End Mark. And PROG terminal is controlled by three values, H (High Level), M (Middle Level), and L (Low Level). Fig. 2 The upper part shows the control sequence diagram of the PROG terminal, and the lower part shows the sequence diagram of the DAT terminal and CLK terminal when the writing circuit example of Fig. 1 is used.

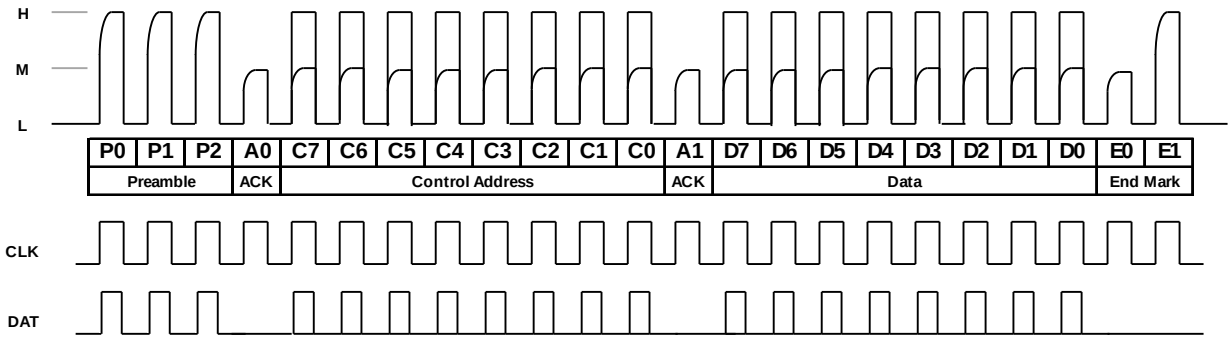


Fig 2. A control sequence of PROG terminal.

Wait Condition

The NJU72097 is wait condition when the CLK is “L”, the DAT is “L” and the PROG terminal is “L” which is 0 [V] for 2msec or more.

Preamble

The serial control function of NJU72097 is activated by inputting three H level pulses (P0, P1, P2,). Then, the EN of the internal circuit in Fig. 1 becomes H, and the PROG terminal voltage is pulled down by the internal resistance of 3.9 kΩ. Furthermore, by inputting the M level pulse at the timing of A0, the PROG terminal voltage becomes M (about 1/2Vprog [V]). By monitoring the PROG terminal voltage with the MCU, you can check the operating status of the NJU72097. If an error occurs, the PROG terminal voltage A0 becomes H (Vprog [V]).

Control Address

The NJU72097 is controlled by sending an 8-bit Control Address (C7 to C0).
If the control address is successfully read, the PROG terminal voltage of A1 becomes M (about 1/2Vprog [V]) by inputting the M level pulse at the timing of A1. If an error occurs, the PROG terminal voltage will be H (Vprog [V]).

Data

8-bit serial data (D7 to D0) sent to the internal register of NJU72097. The data truth table is shown in Tables 1 and 2.

In READ mode, M level 8-bit serial Data (D7 to D0) is transmitted and the data signal that appears as the PROG terminal voltage is read out. Table 3 shows the relationship between the transmitted data and the read data in the circuit shown in Fig. 1.

Table 3. Truth table of transmitted data and read data in READ mode

send data		Read data	
CLK	**DAT**	**PROG terminal voltage**	**Assigned logical value**
H	L	H: Vprog [V]	1
H	L	M: 1/2Vreg [V]	0

End Mark

After sending the control address with the 1-byte command and sending or receiving data with the 2-byte command, you can confirm that the communication has ended by monitoring the PROG terminal voltage with the MCU. If the M level is transmitted at the timing of E0 and E1, the PROG terminal voltage will be M level (about 1/2 Vprog [V]) at E0 and H (Vprog [V]) at E1.If an error occurs, the value will be different.

■ CHARACTERISTICS OF I/O STAGES FOR SERIAL BUS (PROG)

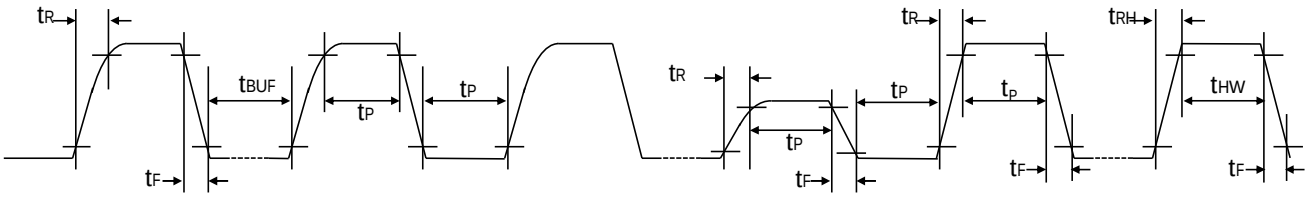
(V_S = 8V, R_L = 680Ω, R_{INF} = R_{INL}= 6.2kΩ, R_{FBF} = 6.2kΩ, R_{FBL} = 180kΩ, R_D = 27kΩ, V_{PROG} = 5V, R_{PULLUP_DATA} = 3.9kΩ, T_a = 25°C unless otherwise noted.)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
High Level Input Voltage	V_{IH}	4.5	5.0	5.5	V
High Level Input Voltage for OTP Writing	V_{IHW}	4.8	5.0	5.2	V
Low Level Input Voltage	V_{IL}	0.0	-	0.3	V
Middle Level Output Voltage	V_O	2.25	-	2.75	V
Supply Current for OTP Writing	I_{WRITE}	-	-	100	mA

■ CHARACTERISTICS OF BUS LINE (PROG) FOR SERIAL BUS DEVICES

(V_S =8V, R_L = 680Ω, R_{INF} = R_{INL} = 6.2kΩ, R_{FBF} = 6.2kΩ, R_{FBL} = 180kΩ, R_D = 27kΩ, V_{PROG} = 5V, R_{PULLUP_DATA} = 3.9kΩ, T_a = 25°C unless otherwise noted.)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Clock Frequency	f_{PROG}	-	50	-	kHz
Rise Time	t_R	-	-	1	µsec
Rise time for OTP Writing	t_{RH}	-	-	300	nsec
Fall time	t_F	-	-	300	nsec
Pulse Width	t_P	4.7	-	10.5	µsec
High Level Pulse Width for OTP Writing	t_{HW}	9.5	10.0	10.5	µsec
Bus free time between the End Mark and the Preamble	t_{BUF}	2	-	-	msec



E1 **P0** **P1, P2** **C7-C0** **C7-C0** **D7-D0**

D7-D0

■ APPLICATION NOTES

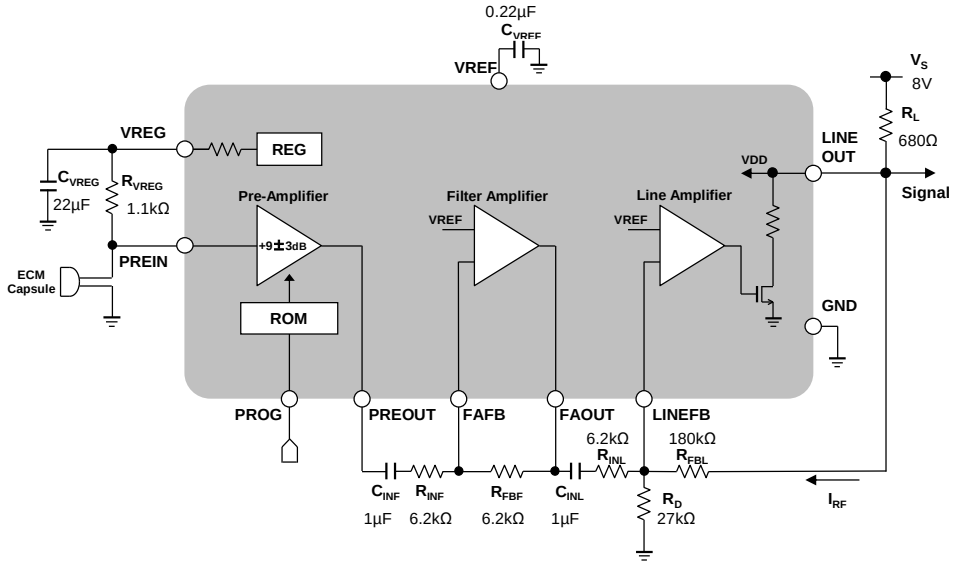


Fig. 1 Application circuit example

1. Supply Voltage of Vs

The recommended supply voltage of Vs is as follows:

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage	V_S		-	8	-	V

2. Voltage Gain

2.1 Pre-Amplifier

$G_{VP} = 9$ [dB]

2.2 Filter Amplifier

$$G_{VP} = 20 \cdot \mathrm{Log}\left(\frac{R_{FBF}}{R_{INF}}\right) \text{ [dB]} \qquad \text{Ex. } G_{VF} = 20 \cdot \mathrm{Log}\left(\frac{6.2k}{6.2k}\right) = 0 \text{ [dB]}$$

2.3 Line Amplifier

$$G_{VL} = 20 \cdot \mathrm{Log}\left(\frac{R_{FBL}}{R_{INL}}\right) \text{ [dB]} \qquad \text{Ex. } G_{VL} = 20 \cdot \mathrm{Log}\left(\frac{180k}{6.2k}\right) \approx 29.3 \text{ [dB]}$$

$$V_{OUT} = V_{REF} \cdot \left(1 + \frac{R_{FBL}}{R_D}\right) \text{ [V]} \qquad \text{Ex. } V_{OUT} = 614m \cdot \left(1 + \frac{180k}{27k}\right) \approx 4.7 \text{ [V]}$$

2.4 NJU72097

$$G_V = G_{VP} + G_{VF} + G_{VL} = G_{VP} + 20 \cdot \mathrm{Log}\left(\frac{R_{FBF}}{R_{INF}} \cdot \frac{R_{FBL}}{R_{INL}}\right) \text{ [dB]}$$

$$\text{Ex. } G_V = 9 + 20 \cdot \mathrm{Log}\left(\frac{6.2k}{6.2k} \cdot \frac{180k}{6.2k}\right) \approx 38.3 \text{ [dB]}$$

Note) The value of R_{VREG} should use 1.1kΩ. Do not use 2.2kΩ.

3. Output Voltage Range

3.1 High side minimum saturation voltage V_{Hsat}

$I_{RF} = \frac{V_{OUT}}{R_{FBL} + R_D}$ ··· Current for feedback resistor R_{FBL}, R_D

Ex. $I_{RF} = \frac{4.7}{180k + 27k} \approx 23$ [μA]

$V_{Hsat} = (I_{DD2} + I_{RF}) \cdot R_L$ [V]

Ex. $V_{Hsat} = (280\mu + 23\mu) \cdot 680 \approx 0.2$ [V]

3.2 Low side minimum saturation voltage V_{Lsat}

$V_{Lsat} \approx 2.15$ [V] (typ.) at $T_a = 25°C$

3.3 Output Voltage Range V_O

$V_O = V_S - (V_{Hsat} + V_{Lsat})$ [V]

Ex. $V_O = 8 - (0.2 + 2.15) = 5.65$ [V_{PP}] ≈ 2.0 [Vrms]

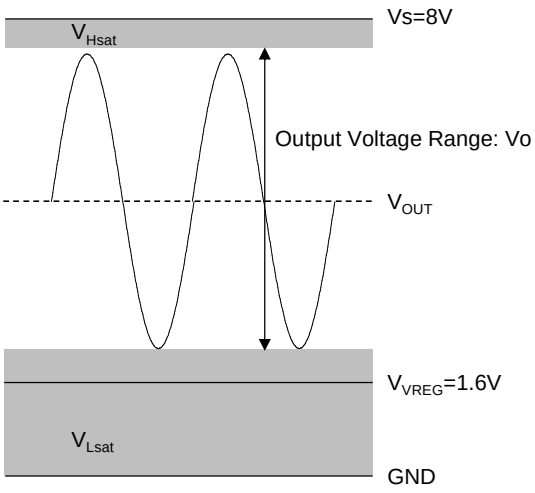
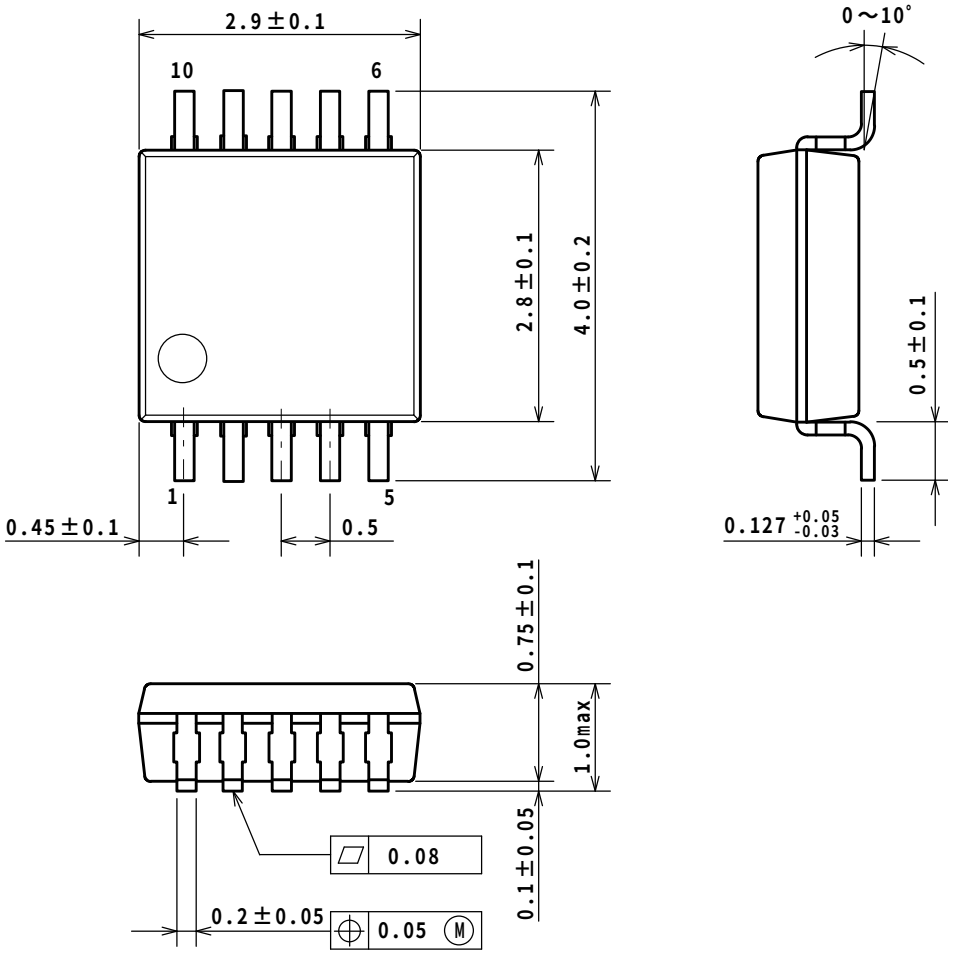


Fig. 2 Output Voltage Range

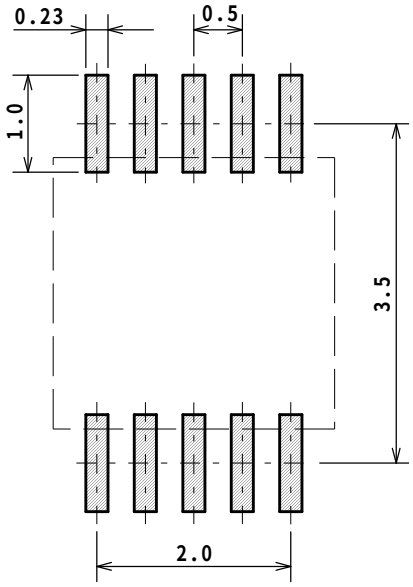
MSOP10 (TVSP10) MEET JEDEC MO-187-DA/THIN TYPE

■ PACKAGE DIMENSIONS

Unit: mm



■ EXAMPLE OF SOLDER PADS DIMENSIONS

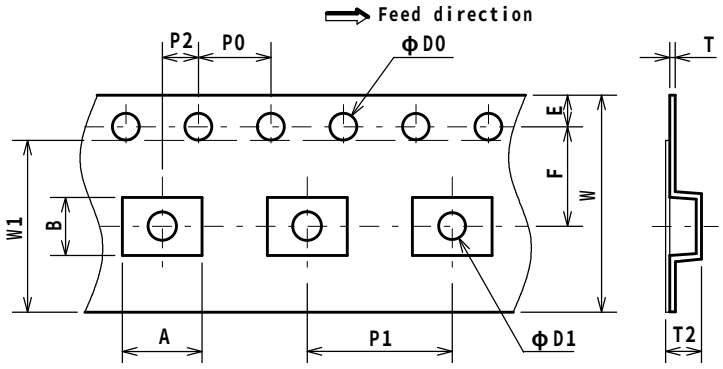


MSOP10 (TVSP10) MEET JEDEC MO-187-DA/THIN TYPE

■ PACKING SPEC

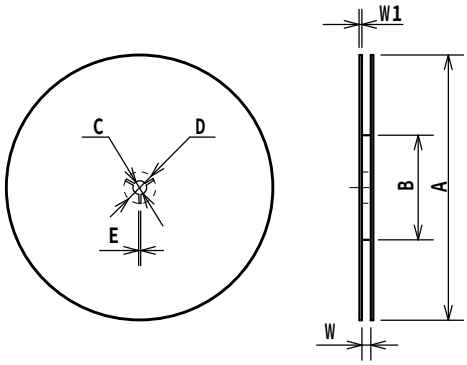
Unit: mm

TAPING DIMENSIONS



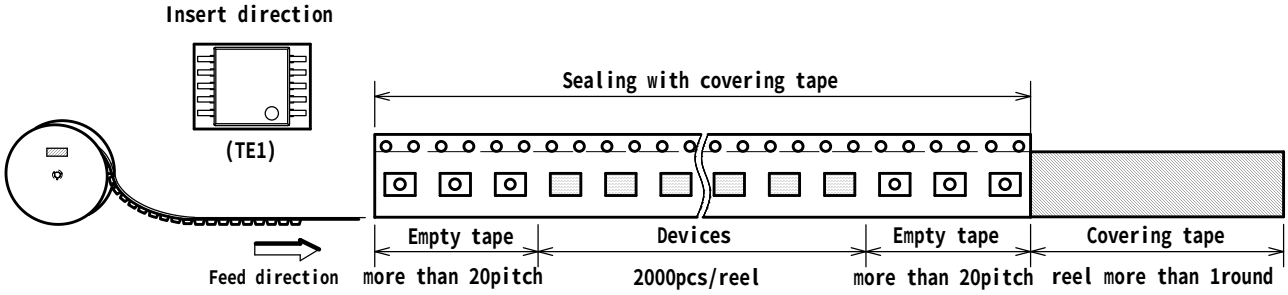
SYMBOL	DIMENSION	REMARKS
A	4.4	BOTTOM DIMENSION
B	3.2	BOTTOM DIMENSION
D0	$1.5^{+0.1}_{0}$	
D1	$1.5^{+0.1}_{0}$	
E	1.75±0.1	
F	5.5±0.05	
P0	4.0±0.1	
P1	8.0±0.1	
P2	2.0±0.05	
T	0.3±0.05	
T2	1.75 (MAX.)	
W	12.0±0.3	
W1	9.5	THICKNESS 0.1max

REEL DIMENSIONS

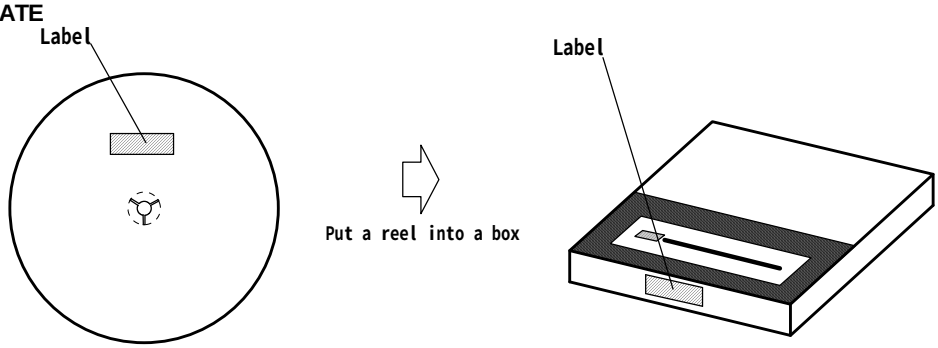


SYMBOL	DIMENSION
A	φ254±2
B	φ100±1
C	φ 13±0.2
D	φ 21±0.8
E	2±0.5
W	13.5±0.5
W1	2.0±0.2

TAPING STATE

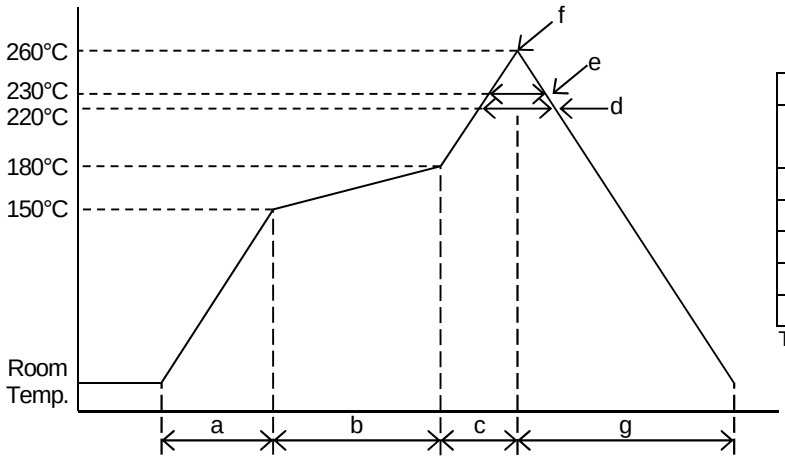


PACKING STATE



■ RECOMMENDED MOUNTING METHOD

INFRARED REFLOW SOLDERING PROFILE



a	Temperature ramping rate	1 to 4°C/s
b	Pre-heating temperature Pre-heating time	150 to 180°C 60 to 120s
c	Temperature ramp rate	1 to 4°C/s
d	220°C or higher time	shorter than 60s
e	230°C or higher time	shorter than 40s
f	Peak temperature	lower than 260°C
g	Temperature ramping rate	1 to 6°C/s

The temperature indicates at the surface of mold package.

■ REVISION HISTORY

DATE	REVISION	CHANGES
December 7, 2020	Ver.1.0	Initial release

[CAUTION]

1. NJR strives to produce reliable and high quality semiconductors. NJR's semiconductors are intended for specific applications and require proper maintenance and handling. To enhance the performance and service of NJR's semiconductors, the devices, machinery or equipment into which they are integrated should undergo preventative maintenance and inspection at regularly scheduled intervals. Failure to properly maintain equipment and machinery incorporating these products can result in catastrophic system failures

2. The specifications on this datasheet are only given for information without any guarantee as regards either mistakes or omissions. The application circuits in this datasheet are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial property rights.
   All other trademarks mentioned herein are the property of their respective companies.

3. To ensure the highest levels of reliability, NJR products must always be properly handled.
   The introduction of external contaminants (e.g. dust, oil or cosmetics) can result in failures of semiconductor products.

4. NJR offers a variety of semiconductor products intended for particular applications. It is important that you select the proper component for your intended application. You may contact NJR's Sale's Office if you are uncertain about the products listed in this datasheet.

5. Special care is required in designing devices, machinery or equipment which demand high levels of reliability. This is particularly important when designing critical components or systems whose failure can foreseeably result in situations that could adversely affect health or safety. In designing such critical devices, equipment or machinery, careful consideration should be given to amongst other things, their safety design, fail-safe design, back-up and redundancy systems, and diffusion design.

6. The products listed in this datasheet may not be appropriate for use in certain equipment where reliability is critical or where the products may be subjected to extreme conditions. You should consult our sales office before using the products in any of the following types of equipment.

   - Aerospace Equipment
   - Equipment Used in the Deep Sea
   - Power Generator Control Equipment (Nuclear, steam, hydraulic, etc.)
   - Life Maintenance Medical Equipment
   - Fire Alarms / Intruder Detectors
   - Vehicle Control Equipment (Airplane, railroad, ship, etc.)
   - Various Safety Devices

7. NJR's products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. NJR shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products. The products are sold without warranty of any kind, either express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose.

8. Warning for handling Gallium and Arsenic (GaAs) Products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.

9. The product specifications and descriptions listed in this datasheet are subject to change at any time, without notice.