Discontinued Product

OKI Semiconductor

This version: Jan. 1998
Previous version: Nov. 1996

# MSM6889

**Multi-Function Telecommunication LSI**

## GENERAL DESCRIPTION

The MSM6889 is best suited to be used as a signal transmitter/receiver LSI for a telemetering system that employs a no-ringing communication system.

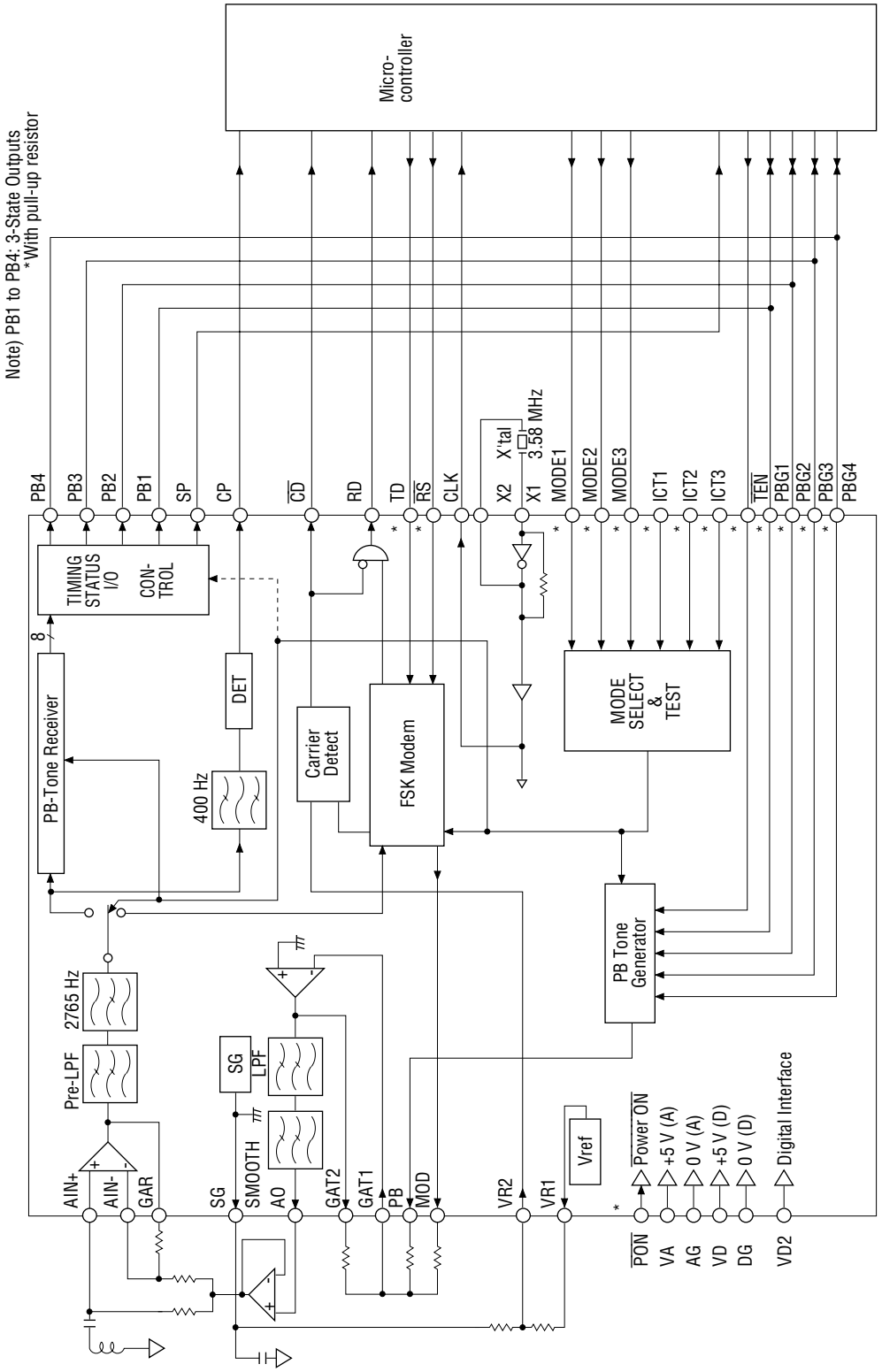
The meter terminal of a telemetering system consists of this device, meter, NCU, and communication controller.

The MSM6889 contains a PB tone detector, a call progress tone (CPT) detector, a PB tone generator, and a 300-bps full-duplex modem conforming to ITU-T V.21.

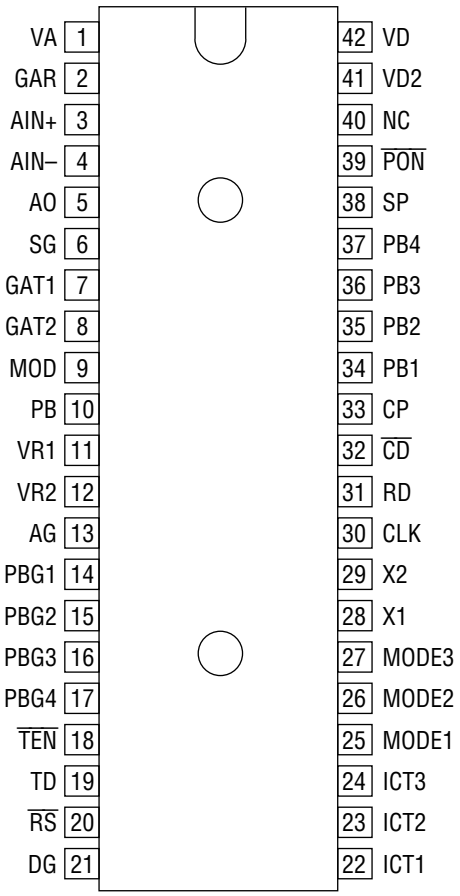
## FEATURES

- Power supply : +5 V ±10%, +2.5 V or higher for digital interface.
- Power consumption
  Operating mode : 9 mA Typ., 12 mA Max.
  Power down mode : 0.1 mA Max.
- The operating mode can be selected from PB tone transmit, PB tone detect, and FSK modem (answer/originate). The FSK modem cannot be operated concurrently with other functions. Modem test modes are also available.
- The call progress tone (CPT) detector operates in PB tone transmit mode or in FSK modem mode.
- PB receiver output is 3-state, and externally connectable to 4-bit input for PB tone generator through the bus line.
- Modem transmit/receive data, carrier detect, request to send, and call progress tone detect have their dedicated pins.
- Prefilter and smoothing filter are provided in analog input and output.
- On-chip 3.579545 MHz crystal oscillator
- 3.579545 MHz master clock output pin (CMOS compatible)
- Power down mode
- Modem : Conforms to ITU-T V.21 (300 bps, full-duplex)
- Transmit analog signals (modem signal, DTMF tone) : Level is independently adjustable externally. Carrier detect level is also adjustable externally.
- Package options:
  42-pin plastic DIP (DIP42-P-600-2.54) (Product name : MSM6889RS)
  56-pin plastic QFP (QFP56-P-1519-1.00-K) (Product name : MSM6889GS–K)

## BLOCK DIAGRAM

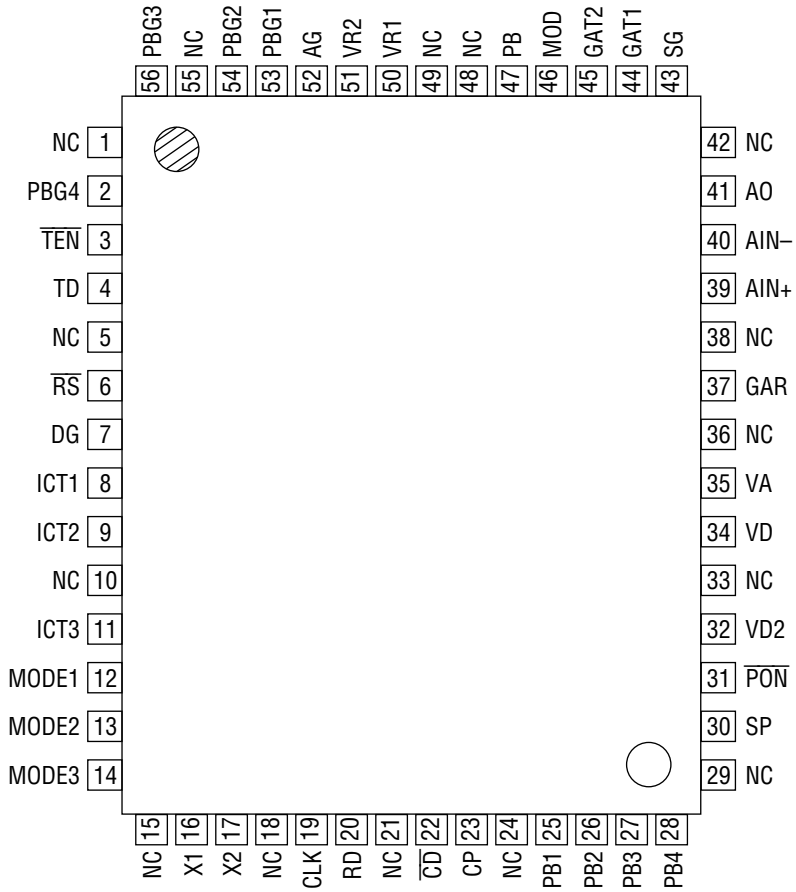


## PIN CONFIGURATION (TOP VIEW)




42-Pin Plastic DIP

NC : No connect pin




56-Pin Plastic QFP

NC : No connect pin

## PIN DESCRIPTION

| Pin Number | | Name | I/O | Description |
|---|---|---|---|---|
| RS | GS | | | |
| 1 | 35 | VA | — | +5 V Power Supply (Analog Circuit).<br>When power is turned on or the power down mode is released, the device must be put into the PB tone transmit mode or PB tone detect mode. |
| 2 | 37 | GAR | O | Output, non-inverting input and inverting input pins of on-chip operational amplifier.<br>No hybrid transformer is required by use of these pins. (See Fig. 2.) |
| 3 | 39 | AIN+ | I | |
| 4 | 40 | AIN– | I | |
| 5 | 41 | AO | O | Analog signal output.<br>PB tone or modem transmit signal is output from this pin. |
| 6 | 43 | SG | O | On-chip signal ground, having a potential of about +2.5 V. |
| 7 | 44 | GAT1 | I | PB is the PB tone output and MOD is the modem signal output.<br>By connecting external resistors to GAT1 and GAT2 pins, signal level can be set at required values for the modem signal and the PB tone that are output from AO, independently. (See Fig. 3.) |
| 8 | 45 | GAT2 | O | |
| 9 | 46 | MOD | O | |
| 10 | 47 | PB | O | |
| 11 | 50 | VR1 | O | These pins are used to externally adjust the received carrier detect(CD) signal level.<br>The potential of VR1 to SG is about +1.1 V. The carrier detect level can be set at the required value by a on-chip resistor divider between VR1 and SG. The given potential to VR2 is set about +0.88 V with high resistance inside the IC. (See Fig. 4.) |
| 12 | 51 | VR2 | I | |
| 13 | 52 | AG | — | Analog Ground, 0 V. |
| 14 | 53 | PBG1 | I* | Inputs used to specify PB tone to be sent.<br>PB1 to PB4 can be connected externally like 4-bit bus line. Data is latched at the falling edge of $\overline{TEN}$. (See Fig. 7 and Fig. 8.) |
| 15 | 54 | PBG2 | I* | |
| 16 | 56 | PBG3 | I* | |
| 17 | 2 | PBG4 | I* | |

* Digital input pulled up by a high resistance inside the IC.

| Pin Number | | Name | I/O | Description |
|---|---|---|---|---|
| RS | GS | | | |
| 18 | 3 | $\overline{TEN}$ | I* | PB tone transmit enable.<br>PBG1 to PBG4 data are latched at the falling edge of $\overline{TEN}$, and PB tone is generated at digital "0" level. (See Fig. 7.) |
| 19 | 4 | TD | I* | Modem transmit serial data input.<br>Data stream less than 300 bps should be input.<br>Digital "1" and "0" correspond to "Mark" and "Space" respectively. |
| 20 | 6 | $\overline{RS}$ | I* | Request to send data input .<br>While $\overline{RS}$ is at digital "0" level, modem transmit is enabled. |
| 21 | 7 | DG | — | Digital Ground, 0 V. |
| 22 | 8 | ICT1 | I* | Input used to select call progress tone (CPT) detect output waveform. (See Fig. 9.) |
| 23 | 9 | ICT2 | I* | Used to check performance characteristics of the IC.<br>Independent of operating mode. Leave these pins open. |
| 24 | 11 | ICT3 | I* | |
| 25 | 12 | MODE1 | I* | Inputs used to specify operating mode.<br>(See Table 1.) |
| 26 | 13 | MODE2 | I* | |
| 27 | 14 | MODE3 | I* | |
| 28 | 16 | X1 | I | 3.579545 MHz crystal resonator should be connected to X1 and X2. When applying external clock to the device, it should be connected to X2 through the AC coupling capacitor of 100 pF and X1 has to be open. |
| 29 | 17 | X2 | O | |
| 30 | 19 | CLK | O | 3.579545 MHz clock output. |
| 31 | 20 | RD | O | Modem receive serial data output.<br>Digital "1" and "0" correspond to "Mark" and "Space" respectively.<br>When $\overline{CD}$ (Carrier Detect) is off, RD is hold at "Mark" state. |
| 32 | 22 | $\overline{CD}$ | O | Carrier Detect output.<br>Digital "0" and "1" represent "Detect" and "No-detect" respectively. |

* Digital input pulled up by a high resistance inside the IC.

| Pin Number | | Name | I/O | Description |
|---|---|---|---|---|
| RS | GS | | | |
| 33 | 23 | CP | O | Call progress tone (CPT) detect output.<br>When a CPT is detected, the waveform selected by ICT1 is output.<br>(See Fig. 9. ) |
| 34 | 25 | PB1 | O | Receive PB tone code outputs.<br>The output impedance of these pins becomes high except when the device operates as PB tone receiver. (See Fig. 7 and Fig. 8. ) |
| 35 | 26 | PB2 | O | |
| 36 | 27 | PB3 | O | |
| 37 | 28 | PB4 | O | |
| 38 | 30 | SP | O | PB tone receive data present.<br>Digital "1" represents that this pin is receiving the PB tone.<br>(See Fig. 8. ) |
| 39 | 31 | $\overline{\text{PON}}$ | I | Power down mode select. Digital "1" on this pin puts the whole circuit of the device into the power down state. |
| 40 | — | NC | — | No connection. |
| 41 | 32 | VD2 | — | Power supply for digital interface output.<br>The supply voltage from +2.5 V to VD is possible for VD2. For example, when the device interfaces to the MCU working on +3 V supply, the +3 V supply has to be applied to the VD2 pin.<br>Note that this function is effective to all of digital output pins except X1, X2, and CLK.<br>There is no restriction regarding the power supplies (VD and VD2) applying procedure. |
| 42 | 34 | VD | — | +5 V power supply (digital circuit).<br>When power is turned on or the power down mode is released, the device must be put into the PB tone transmit mode or PB tone detect mode. |

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Condition | Rating | Unit |
|---|---|---|---|---|
| Power Supply Voltage | VA, VD | Ta = 25°C with respect to AG and DG | –0.3 to 7 | V |
| | VD2 | | –0.3 to VD | |
| Input Pin Voltage | | | –0.3 to VA(VD) + 0.3 | |
| Storage Temperature | | — | –65 to 150 | °C |
| Pin Soldering Temperature | | Within 10 sec | 260 | |

## RECOMMENDED OPERATING CONDITIONS

| Parameter | | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Power Supply Voltage | | VA, VD | — | 4.5 | 5.0 | 5.5 | V |
| | | VD2 | | 2.5 | — | VD | |
| Digital Input Voltage | | $V_{IH}$ | — | 2.0 | — | VD | V |
| | | $V_{IL}$ | | 0 | — | 0.8 | |
| Digital Output Current | | $I_{OH}$ | When VD2 = VD (excluding) X2 | –0.05 | — | — | mA |
| | | $I_{OL}$ | | — | — | 0.4 | |
| Operating Temperature | | $T_{op}$ | — | –40 | — | +85 | °C |
| Input Clock Frequency | | $f_{CLK}$ | — | –0.1 | — | +0.1 | % |
| Bypass Capacitance | | VA | — | 0.1 + 10 | — | — | µF |
| | | VD, VD2 | | 1 | — | — | |
| Crystal | Frequency Deviation | | At 25°C ±5°C | –100 | — | +100 | ppm |
| | Temperature Characteristics | | At –40°C to ±85°C | –50 | — | +50 | |
| | Equivalent Series Resistance | | — | — | — | 50 | Ω |
| | Load Capacitance | | — | — | 16 | — | pF |

## ELECTRICAL CHARACTERISTICS

### DC and Digital Interface Characteristics

(VA, VD, VD2 = +5 V ±10%, Ta = –40°C to +85°C)

| Parameter | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Power Supply | $I_{AD}$ | $I_A + I_D + I_{D2}$ | $\overline{PON}$ = "0" | — | 9 | 12 | mA |
| Current | $I_{PD}$ | (VD2 = VD) | $\overline{PON}$ = "1" | — | 0.01 | 0.1 | mA |
| Digital Input | $I_{IH}$ | VD2 = VD | $V_I = V_{IH}$ Max. | –10 | — | 10 | µA |
| Current* | $I_{IL}$ | | $V_I = V_{IL}$ Min. | –100 | — | 10 | |
| Digital Output | $V_{OH}$ | | $I_O = I_{OH}$ Min. | 2.4 | — | VD2 | V |
| Voltage | $V_{OL}$ | | $I_O = I_{OL}$ Max. | 0 | — | 0.4 | |

* Internal pull-up resistor

### Analog Interface and Dynamic Characteristics

(VD = VA = 5 V ±10%, Ta = –40°C to +85°C)

| Parameter | Condition | | | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| Modem Transmit Level | MOD | $R_L \geq 20$ kΩ | | | –3 | –1 | +1 | dBm |
| | | "Mark" and "Space" Signals | | | 1.55 | 1.95 | 2.46 | $V_{P-P}$ |
| PB Tone Send Level | PB | $R_L \geq 20$ kΩ | Low-Group Tone | | –8.5 | –6.5 | –4.5 | dBm |
| | | | High-Group Tone | | –7.5 | –5.5 | –3.5 | dBm |
| Output Voltage Swing | AO | $R_L \geq 20$ kΩ | | | 2.2 | 3 | — | Vp-p |
| Output Load Resistance | MOD, PB, GAT2, AO | | | | 20 | — | — | kΩ |
| Signal Level Relative Value | MODEM | "Mark" & "Space" Signals | | | –2 | 0 | 2 | dB |
| | PB Tone | High-Gr. Tone & Low-Gr. Tone | | | 0 | 1 | 2 | dB |
| Output DC Voltage | MOD, PB<br>AO (When GAT1 and GAT2 are connected) | | | | $\frac{VA}{2} - 0.1$ | $\frac{VA}{2}$ | $\frac{VA}{2} + 0.1$ | V |
| Modem Transmit Carrier Frequency | Originate Mode | MARK | TD | "1" | 976 | 980 | 984 | Hz |
| | | SPACE | | "0" | 1176 | 1180 | 1184 | |
| | Answer Mode | MARK | | "1" | 1646 | 1650 | 1654 | |
| | | SPACE | | "0" | 1846 | 1850 | 1854 | |
| Out-of-band Energy | 4 to 8 kHz | P : In-band Signal Energy (0.3 kHz to 3.4 kHz) Measured at primary side of transformer line. | | | — | — | P-20 | dB |
| | 8 to 12 kHz | | | | — | — | P-40 | dB |
| | 12 kHz to | | | | — | — | P-60 | dB |
| PB Tone Frequency | With respect to nominal frequency | | | | –1.5 | — | +1.5 | % |
| PB Tone Distortion | Harmonics/Fundamental | | | | — | — | –23 | dB |
| PBG1 to PBG4 Input Data Setup Time | TPBGS, Fig. 7 | | | | 250 | — | — | ns |
| PBG1 to PBG4 Input Data Hold Time | TPBGH, Fig. 7 | | | | 250 | — | — | ns |

## Analog Interface and Dynamic Characteristics (Continued)

(VD = VA = 5 V ±10%, Ta = –40°C to +85°C)

| Parameter | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Input Impedance | AIN+, 0 to 10 kHz | | 20 | — | — | kΩ |
| Modem Receive Signal Level | AIN+, FSK Demodulator Signal | | — | — | –6 | dBm |
| Carrier Detect (CD) Signal Level | VR2; Open<br>Answer mode: 1080 Hz<br>Originate mode: 1750 Hz | OFF→ON | — | — | –42 | dBm |
| | | ON→OFF | –48 | — | — | dBm |
| CD Level Hysteresis | Answer mode: 1080 Hz<br>Originate mode: 1750 Hz | | 1 | — | — | dB |
| CD Delay Time | –60 dBm → –20 dBm Step | | 10 | — | 40 | ms |
| CD Hold Time | –20 dBm → –60 dBm Step | | 0 | — | 40 | ms |
| Demod. Data Bias Distortion | 300 bps, 1/0 Alternative Pattern | | — | — | ±10 | % |
| NRTS Signal-to-Modem Receive Signal Ratio | vNRTS/v Receive Modem Signal<br>NRTS: 2765 Hz ±30 Hz | | — | — | –2 | dB |
| CPT Detect Level | 400 Hz | | –40 | — | –6 | dBm |
| CPT Non-detect Level | 400 Hz | | — | — | –60 | dBm |
| CPT Detect Frequency | R > 20% (square waves output)<br>(See Fig. 9) | | 380 | — | 420 | Hz |
| CPT Non-detect Frequency | R > 20% (square waves output) | | 500 | — | — | Hz |
| | (See Fig. 9) | | — | — | 300 | |
| CPT Detect Delay Time | — | | — | 20 | — | ms |
| CPT Detect Hold Time | — | | — | 20 | — | ms |
| PB Tone Detect Amplitude | For Each Signal Tone | | –46 | — | –6 | dBm |
| PB Tone Non-detect Amplitude | For Each Signal Tone | | — | — | –60 | dBm |
| Detect Frequency | With respect to Nominal Frequency | | — | — | ±1.5 | % |
| Non-detect Frequency | With respect to Nominal Frequency | | ±3.8 | — | — | % |
| Allowable twist | High-Gr. Tone/Low-Gr. Tone | | –6 | — | +6 | dB |
| Allowable Noise Level | Noise (0.3 kHz to 3.4 kHz)<br>Level/Tone Level | | — | –12 | — | dB |
| Dial Tone Rejection Ratio | 380 Hz to 420 Hz | | 37 | — | — | dB |
| Signal Repetition Time | $T_C$ | Fig. 1 | 120 | — | — | ms |
| Time to Receive | $T_S$ | | 49 | — | — | ms |
| Invalid Tone Duration | $T_I$ | | — | — | 24 | ms |
| Output Delay Time | $T_G$ | | 24 | 39 | 49 | ms |
| Interdigit Pause | $T_P$ | | 30 | — | — | ms |
| Acceptable Drop Out | $T_B$ | | — | — | 2 | ms |
| SP Delay Time | $T_{SP}$ | | 6 | 8 | 10 | ms |
| Output Trailing edge Delay | $T_D$ | | 21 | 28 | 35 | ms |

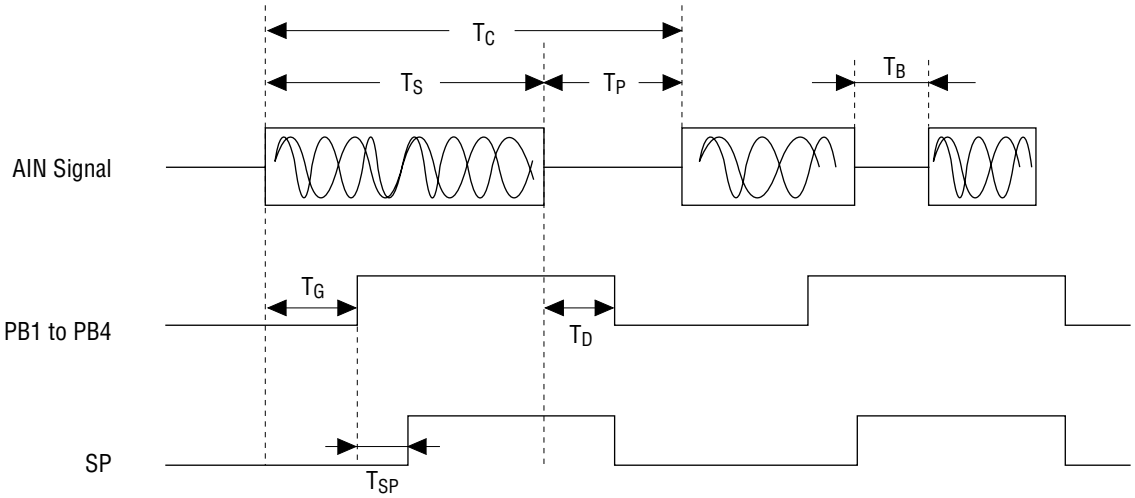



**Figure 1**

## FUNCTIONAL DESCRIPTION AND APPLICATION

### Resistance Hybrid Condition (Ideal Condition)

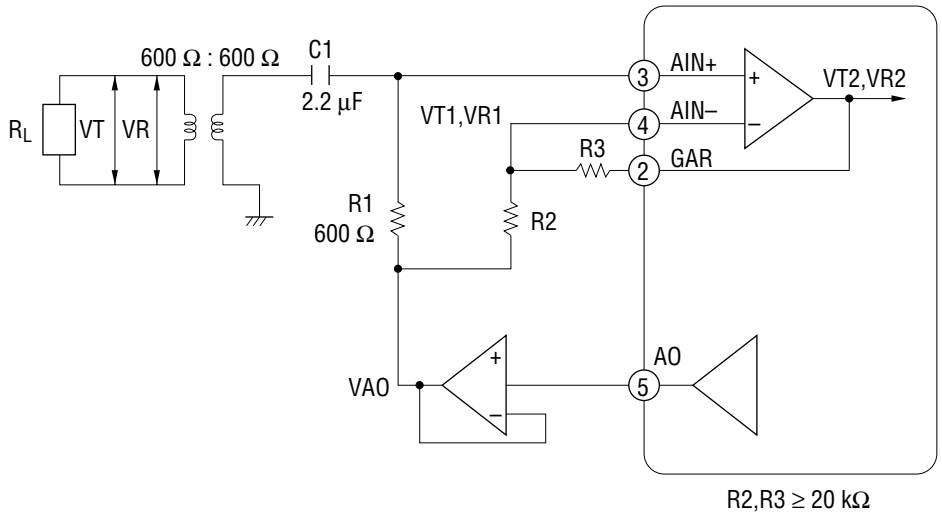



**Figure 2**

C1 is an ignorable impedance in the voice frequency band; therefore, if a line transformer and phone line impedance are ideal ($R_L$ = 600 Ω pure resistance), the signal levels at each point are as shown below.

| | | |
|---|---|---|
| VT, VR | : | Transmit at 2W on phone line, receive signal level (balanced) |
| VT1, VR1 | : | Transmit at pin 3 (AIN+), receive signal level (unbalanced) |
| VAO | : | Transmit signal level at pin 5 (AO) (unbalanced) |
| VT2 | : | Leaking of transmit signal into receive circuit (unbalanced) |
| VR2 | : | Receive signal level of the device (unbalanced) |

1) $VT = VT1 = 1/2 \times VAO$
The transmit signal level (voltage) on phone line is half the level at the output pin (AO) of the device. (600 Ω : a 600 Ω line transformer is used)

2) $VR1 = VR$

3) $VT2 = VT1 \times (1+ \frac{R3}{R2}) + VAO \times (- \frac{R3}{R2})$

$= \frac{1}{2} VAO \times (1+ \frac{R3}{R2}) - VAO \times \frac{R3}{R2} = \frac{1}{2} VAO \times (1- \frac{R3}{R2})$

Then, where R2 = R3 (e.g., 51 kΩ), VT2 = 0.
This means that the transmit signal is no longer leaking into the receive circuit.

4) $VR2 = VR1 \times (1+ \frac{R3}{R2})$ , where R2 = R3, $VR2 = 2 \times VR1 = 2 \times VR$

### Setup of Transmit Signal Levels

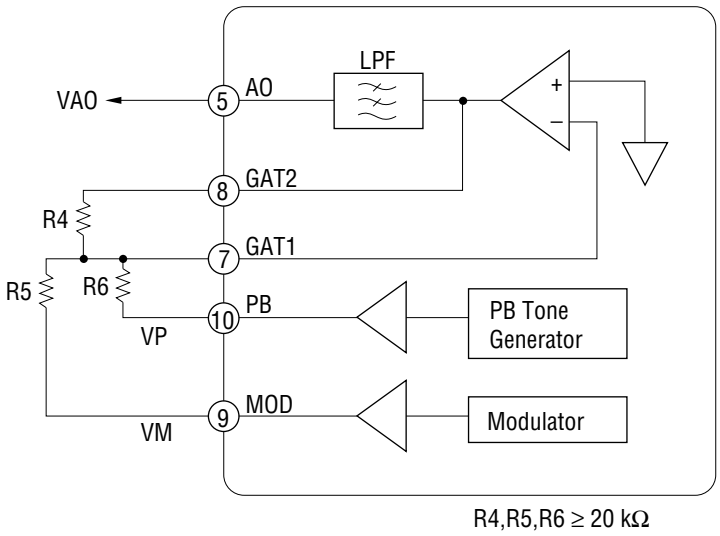



**Figure 3**

The modulation analog signal and PB tone from the modem are not sent at a time. The signal to be sent is determined by the operating mode specified.
This device is provided with the pins for specifying levels of these transmit signals independently. The answer tones, which are generated from MODULATOR, are handled as modem signals.

VM : Modem signal level (voltage) at MOD (pin 9)
VP : PB tone level (voltage) at PB (pin 10)

When the external resistors are R4, R5 and R6, the signal levels at AO (pin 5) are as shown below.

$$\text{VAO (modem)} = \frac{R4}{R5} \times VM$$

$$\text{VAO (PB)} = \frac{R4}{R6} \times VP$$

Note : R4, R5, R6 ≥ 20 kΩ

As described in "Resistance Hybrid Condition", signal levels actually sent over a phone line will be half the above mentioned values under the ideal condition.

### External Setup of Carrier Detect Level

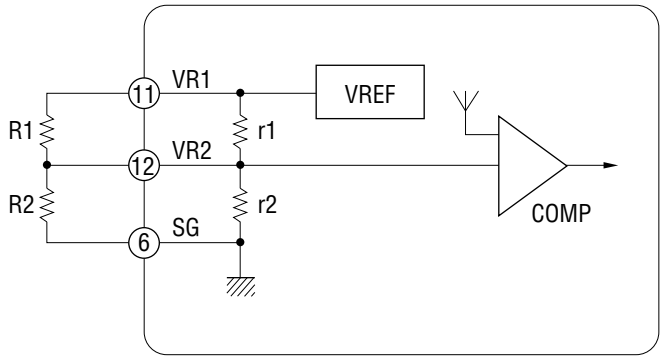



**Figure 4**

### Operating Mode

**Table 1 Operating Mode Table**

| Mode Select | | | Operating Mode | | Functional Block | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CPT REC. | |
| 1 | 2 | 3 | | | PB GEN. | PB REC. | FSK MODEM | ICT1 = "1" | ICT1 = "0" |
| 0 | 0 | 0 | PB Tone Transmit | | * | | | | * |
| 1 | 0 | 0 | PB Tone Detect | | | * | | | |
| 0 | 1 | 0 | Originate Mode Modem (O) | | | | * | * | |
| 1 | 1 | 0 | Answer Mode Modem (A) | | | | * | * | |
| 0 | 0 | 1 | Analog Loop Back Test (ALB) | O | | | * | * | |
| 1 | 0 | 1 | | A | | | * | * | |
| 0 | 1 | 1 | Remote Digtal Loop Back Test (RDLB) | O | | | * | * | |
| 1 | 1 | 1 | | A | | | * | * | |

* : Active
When power is turned on or the power down mode is released, put the device into the PB tone transmit mode or PB tone detect mode.

Signal flow concept for the modem normal operating mode is shown in Fig. 5.

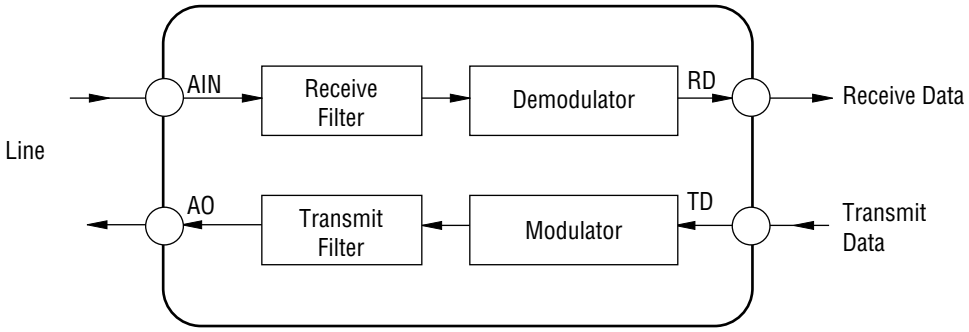



**Figure 5**

In the test modes, signal flow shown in Fig. 6 is used. O/(originate)/A(answer) in the test mode is the expression where the modulator side is referred to as the basis.

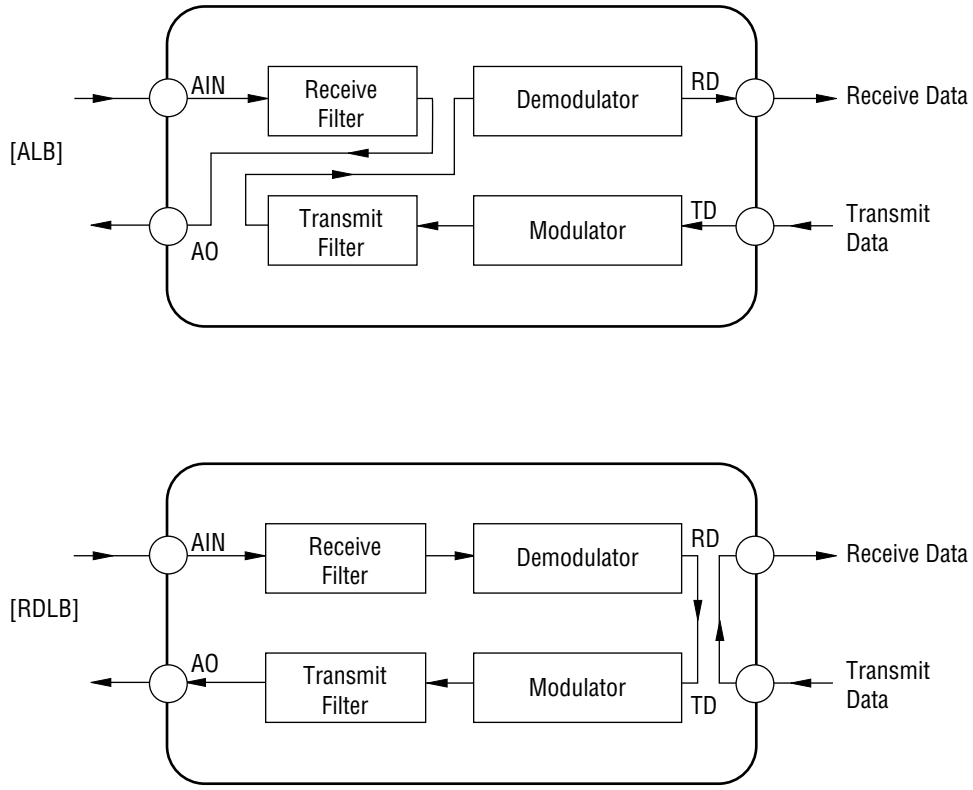



**Figure 6**

### PB Tone Transmit Mode and PB Tone Detect Mode

When PBG1 to PBG4 are externally connected to PB1 to PB4 so as to use them as 4-bit bus lines, their tone generation timings are as shown below.

1) PB Tone Transmit Mode

When $\overline{TEN}$ is in the digital "0" state, PB tone is generated according to Table 2.

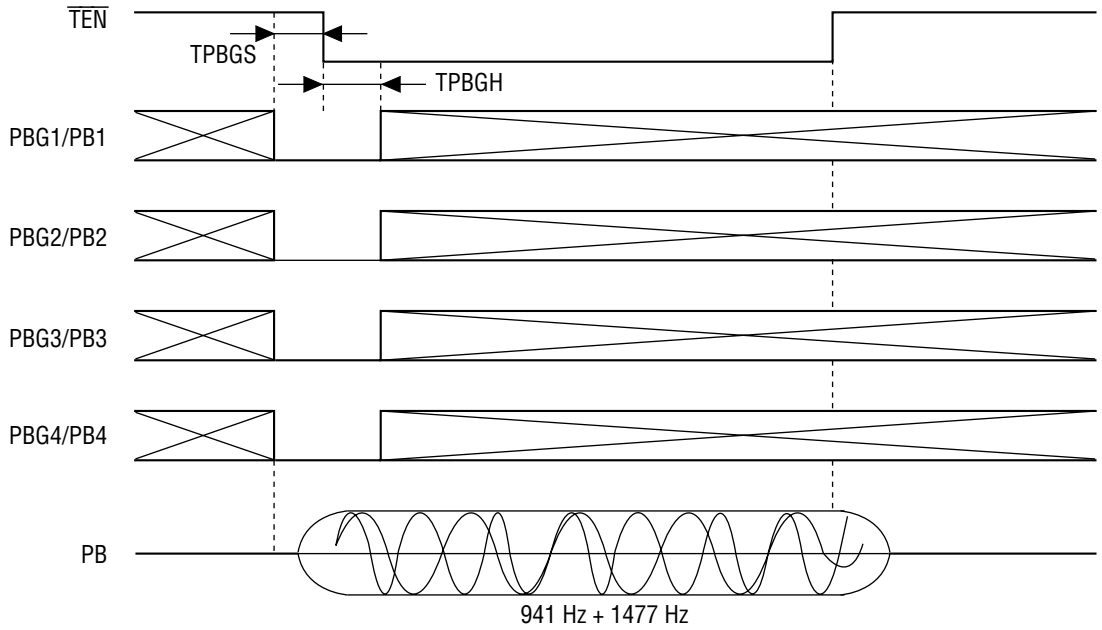



**Figure 7**

2) PB Tone Detect Mode

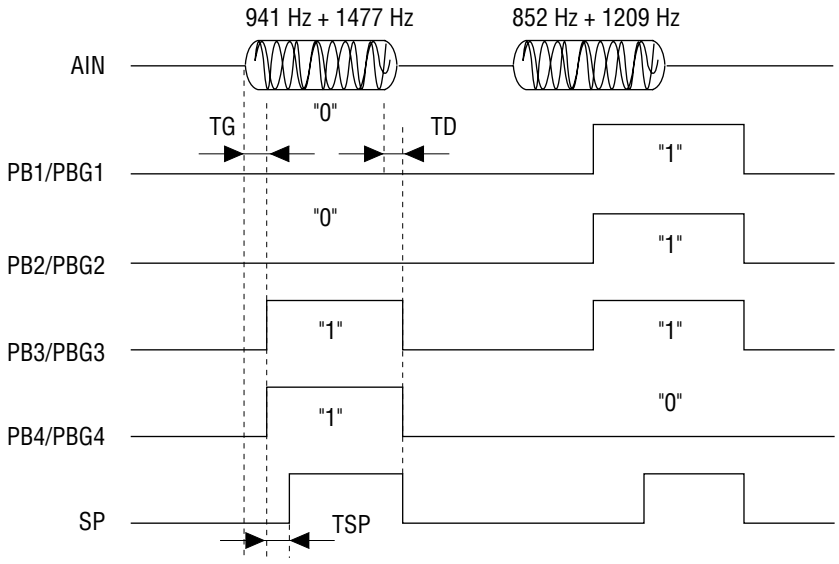



**Figure 8**

**Table 2 PB Tone Code Table**

| Button | Low-Group Freq. (Hz) | | | | High-Group Freq. (Hz) | | | | PB4/ | PB3/ | PB2/ | PB1/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 697 | 770 | 852 | 941 | 1209 | 1336 | 1477 | 1633 | PBG4 | PBG3 | PBG2 | PBG1 |
| 1 | * | | | | * | | | | 0 | 0 | 0 | 1 |
| 2 | * | | | | | * | | | 0 | 0 | 1 | 0 |
| 3 | * | | | | | | * | | 0 | 0 | 1 | 1 |
| 4 | | * | | | * | | | | 0 | 1 | 0 | 0 |
| 5 | | * | | | | * | | | 0 | 1 | 0 | 1 |
| 6 | | * | | | | | * | | 0 | 1 | 1 | 0 |
| 7 | | | * | | * | | | | 0 | 1 | 1 | 1 |
| 8 | | | * | | | * | | | 1 | 0 | 0 | 0 |
| 9 | | | * | | | | * | | 1 | 0 | 0 | 1 |
| 0 | | | | * | | * | | | 1 | 0 | 1 | 0 |
| * | | | | * | * | | | | 1 | 0 | 1 | 1 |
| # | | | | * | | | * | | 1 | 1 | 0 | 0 |
| A | * | | | | | | | * | 1 | 1 | 0 | 1 |
| B | | * | | | | | | * | 1 | 1 | 1 | 0 |
| C | | | * | | | | | * | 1 | 1 | 1 | 1 |
| D | | | | * | | | | * | 0 | 0 | 0 | 0 |

**Call Progress Tone (CPT) Detect Mode**

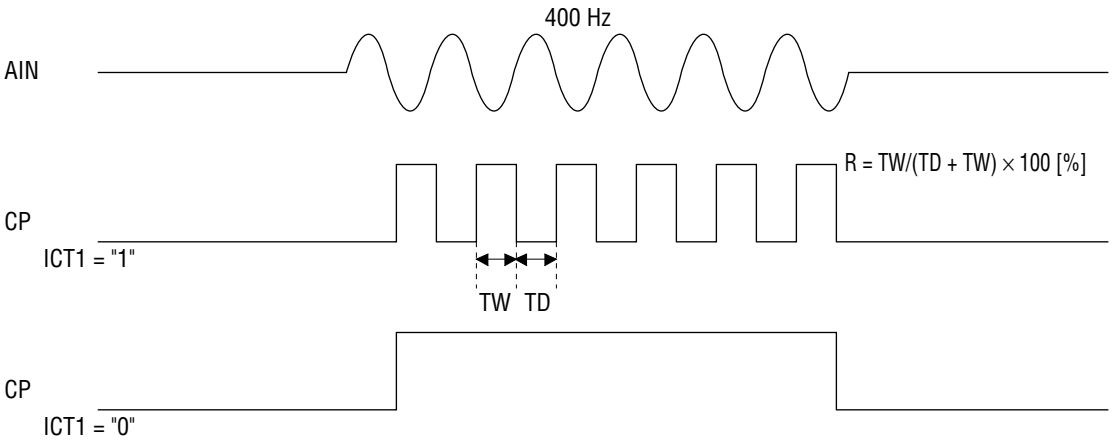
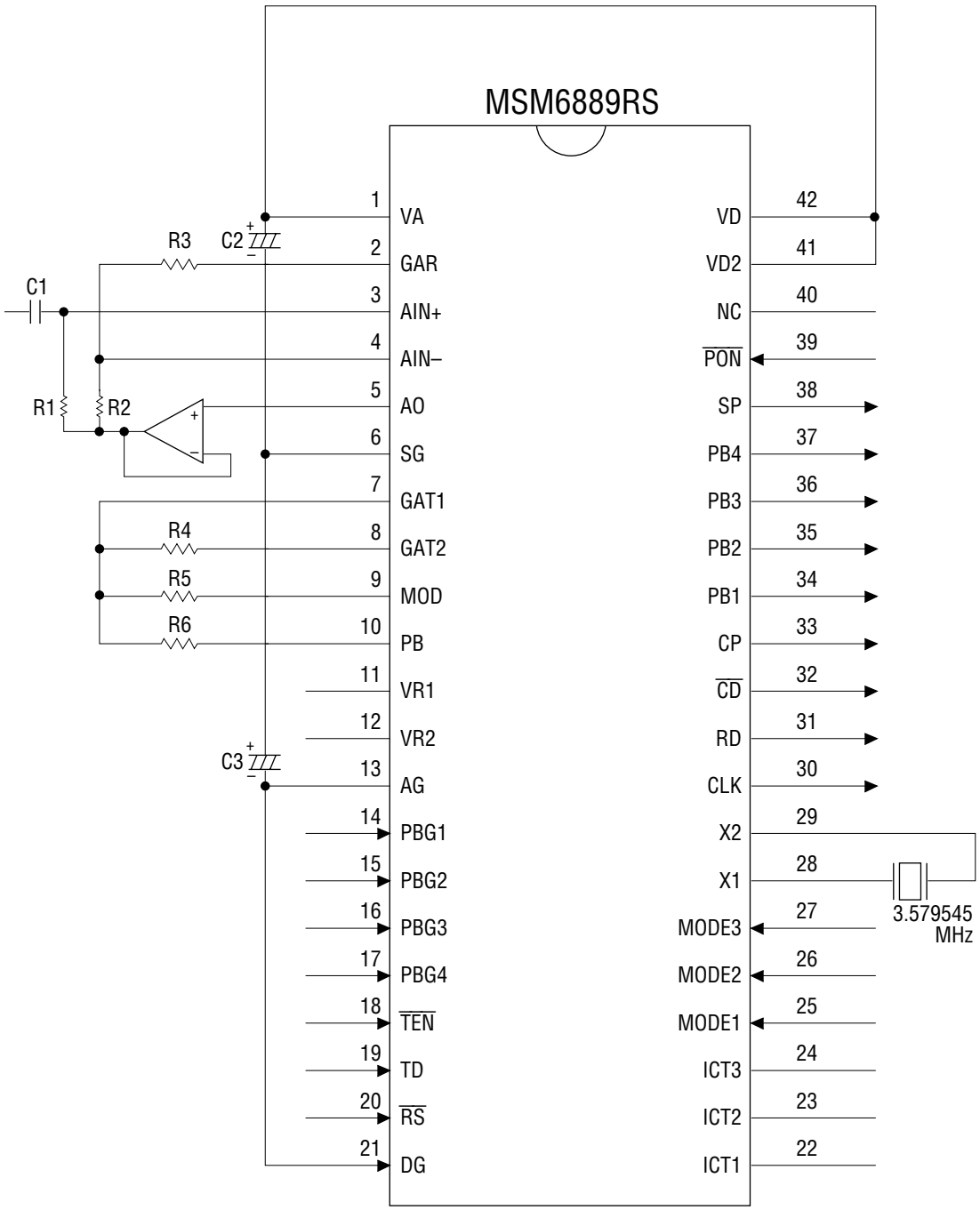



**Figure 9**

## APPLICATION CIRCUIT

### Pin Connection



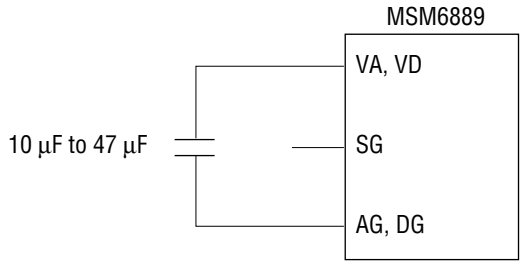

R1 = 600 Ω, R2 = R3 = R4 = R5 = R6 = 51 kΩ
C1 = 2 µF, C2 = C3 = 10 µF

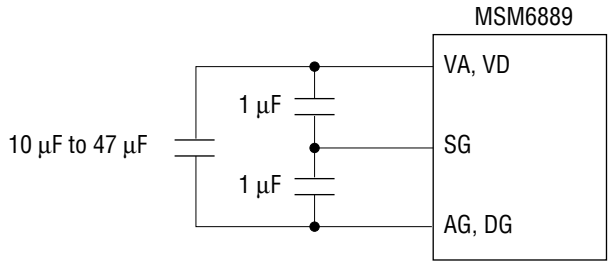
### Bypass Capacitor Connections

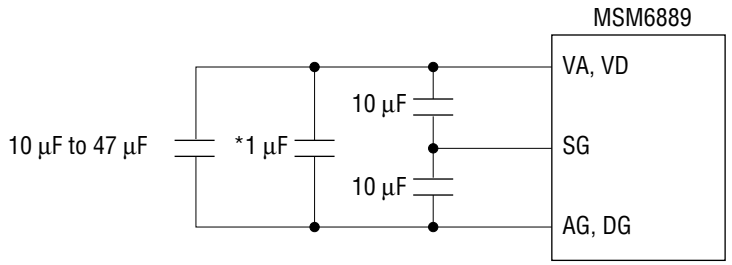
The MSM6889 contains analog circuits.

Note that noise occurred in the power supply by trouble in other circuits may cause degradation in characteristics of the device.

The examples of connected bypass capacitors of the MSM6889 are shown below.



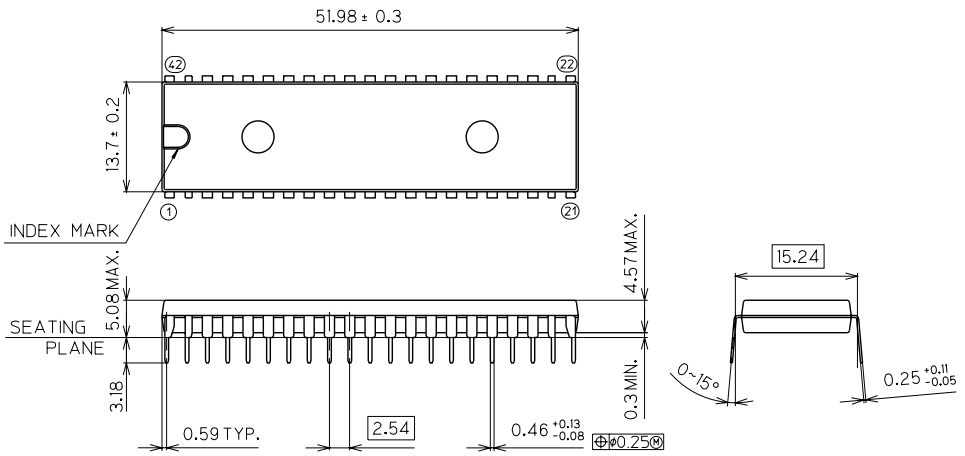




* Laminated ceramic capacitor

## PACKAGE DIMENSIONS

(Unit : mm)

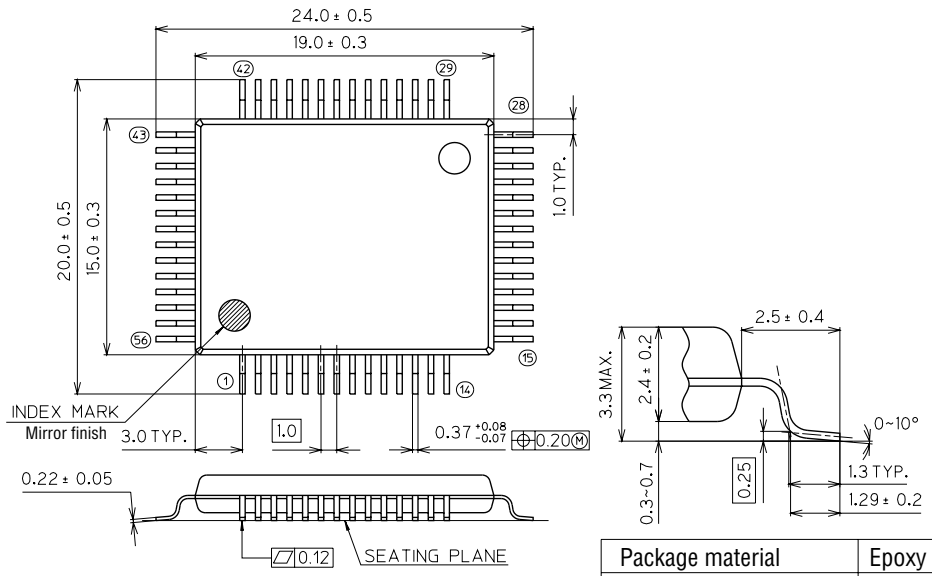
DIP42-P-600-2.54




| | |
|---|---|
| Package material | Epoxy resin |
| Lead frame material | 42 alloy |
| Pin treatment | Solder plating |
| Solder plate thickness | 5 μm or more |
| Package weight (g) | 6.20 TYP. |

(Unit : mm)

QFP56-P-1519-1.00-K




| | |
|---|---|
| Package material | Epoxy resin |
| Lead frame material | 42 alloy |
| Pin treatment | Solder plating |
| Solder plate thickness | 5 μm or more |
| Package weight (g) | 1.46 TYP. |

Notes for Mounting the Surface Mount Type Package

The SOP, QFP, TSOP, SOJ, QFJ (PLCC), SHP and BGA are surface mount type packages, which are very susceptible to heat in reflow mounting and humidity absorbed in storage.
Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).