

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC9455F, TC9455N, TC9488F, TC9488N

Digital Echo IC for Karaoke

The TC9455 series are digital echo ICs for karaoke. The ICs incorporate microphone amps and volume controllers, enabling a digital echo system to be configured on a single chip.

## Features

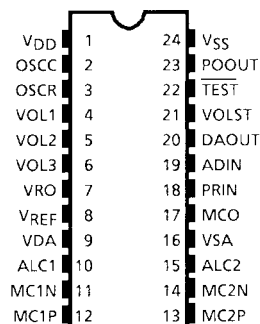
- Incorporates a two-channel microphone amp with auto level control (ALC), AD/DA converter, delay memory, and electronic volume controllers.
- Incorporates a 32-kHz sampling, 12-bit successive comparison AD/DA converter.
- Incorporates a delay memory (16-Kbit DRAM) which enables 128-ms (typ.) delay.
- Microphone and echo levels are controlled by built-in volume controllers. They are controlled either by DC voltage or controlled in serial by the MCU.

TC9455F/N: Supports I<sup>2</sup>C bus interface

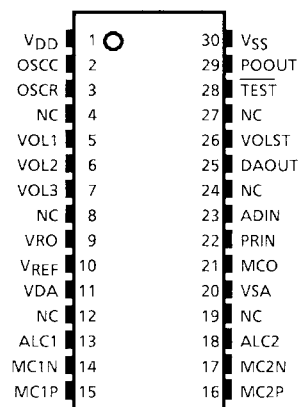
TC9488F/N: Supports three-lead interface

- The system clock is generated by the CR oscillator circuit.
- The echo feedback amount is configured using analog circuits. The feedback level can be freely set.
- The IC comes in 30-pin flat package or 24-pin shrink DIP.

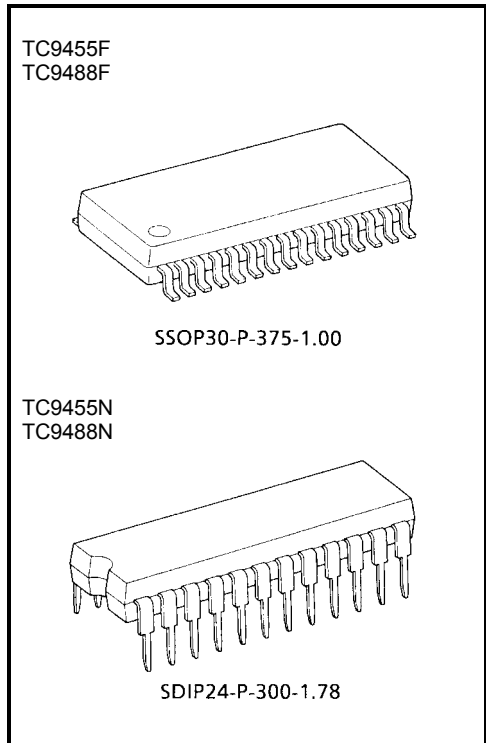
## Pin Connection



TC9455N, TC9488N



TC9455F, TC9488F

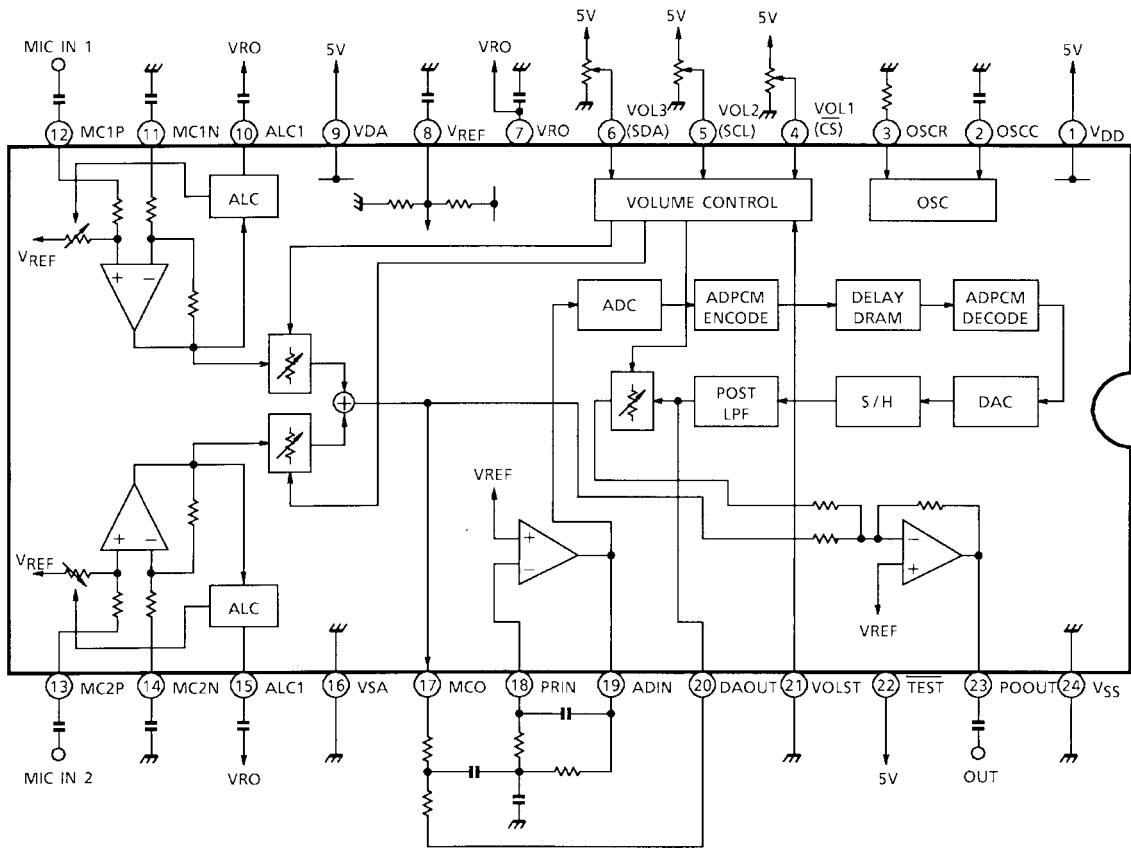


Weight:

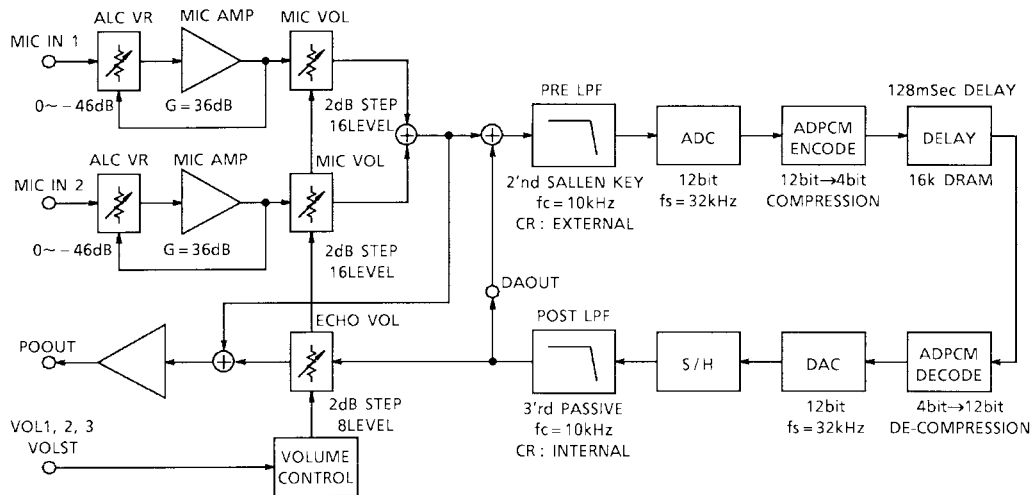
SSOP30-P-375-1.00: 1.08 g (typ.)

SDIP24-P-300-1.78: 1.2 g (typ.)

**Block Diagram**



**System Block Diagram**



## Pin Description (Note 1)

| Pin Number         |                    | Symbol                          | I/O | Function  | Remarks           |
|--------------------|--------------------|---------------------------------|-----|---|-------------------|
| TC9455N<br>TC9488N | TC9455F<br>TC9488F |                                 |     |   |                   |
| 1                  | 1                  | V <sub>DD</sub>                 | —   | Digital supply voltage pin  |                   |
| 2                  | 2                  | CSCC                            | I   | Capacitor connecting pin for CR oscillator (C = 68 pF)  |                   |
| 3                  | 3                  | OSCR                            | I   | Resistor connecting pin for CR oscillator (R = 5.6 kΩ)  |                   |
| 4                  | 5                  | VOL1 ( $\overline{\text{CS}}$ ) | I   | When VOLST = "H" level, $\overline{\text{CS}}$ signal input pin<br>When VOLST = "L" level, DC control pin for MIC1 volume   |                   |
| 5                  | 6                  | VOL2 (SCL)                      | I   | When VOLST = "H" level, clock input pin<br>When VOLST = "L" level, DC control pin for MIC2 volume   | Open drain output |
| 6                  | 7                  | VOL3 (SDA)                      | I   | When VOLST = "H" level, data input pin<br>When VOLST = "L" level, DC control pin for echo volume  | Open drain output |
| 7                  | 9                  | VRO                             | —   | Reference voltage pin   |                   |
| 8                  | 10                 | V <sub>REF</sub>                | —   | Reference voltage pin (1/2 V <sub>DD</sub> )  |                   |
| 9                  | 11                 | VDA                             | —   | Analog supply voltage pin   |                   |
| 10                 | 13                 | ALC1                            | I   | Auto level control pin 1  |                   |
| 11                 | 14                 | MC1N                            | I   | MIC1 feedback signal input pin  |                   |
| 12                 | 15                 | MC1P                            | I   | MIC1 signal input pin   |                   |
| 13                 | 16                 | MC2P                            | I   | MIC2 signal input pin   |                   |
| 14                 | 17                 | MC2N                            | I   | MIC2 feedback signal input pin  |                   |
| 15                 | 18                 | ALC2                            | I   | Auto level control pin 2  |                   |
| 16                 | 20                 | VSA                             | —   | Analog ground pin   |                   |
| 17                 | 21                 | MCO                             | O   | MIC addition signal output pin  |                   |
| 18                 | 22                 | PRIN                            | I   | Pre-filter input pin  |                   |
| 19                 | 23                 | ADIN                            | I   | Pre-filter output signal or DC input pin  |                   |
| 20                 | 25                 | DAOUT                           | O   | Post-filter output pin  |                   |
| 21                 | 26                 | VOLST                           | I   | Electronic volume control mode select pin<br>When VOLST = "H" level, serial control (I <sup>2</sup> C bus/three-lead)<br>When VOLST = "L" level, DC level control |                   |
| 22                 | 28                 | $\overline{\text{TEST}}$        | I   | Test pin. Fix to "H" level for normal use   |                   |
| 23                 | 29                 | POOUT                           | O   | Microphone echo signal output pin   |                   |
| 24                 | 30                 | V <sub>SS</sub>                 | —   | Digital ground pin  |                   |

Note 1: With the TC9455F and TC9488F, pins 4, 8, 12, 19, 24, and 27 are not connected (NC pins).  
NC pins are normally open.

**Operation**

**1. Oscillator circuit**

The TC9455F/N and TC9488F/N generate an internal system clock using the CR oscillator circuit. Connecting a capacitance (C) of 68 pF and a resistance (R) of 5.6 kΩ sets the oscillator frequency to approx. 4 MHz and the sampling frequency to 32 kHz.

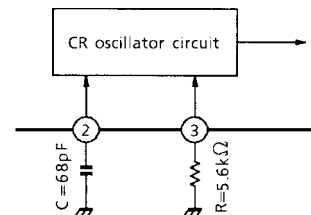
Varying the external capacitance enables the oscillator frequency and sampling frequency for the system clock to be adjusted. Varying the system clock enables the delay time to be adjusted.

Figure 1 shows the CR oscillator circuit.

**1.1 How to determine oscillator frequency (f)**

$$\begin{aligned}
 f \text{ [MHz]} &= 1532 / (C \text{ [pF]} \times R \text{ [k}\Omega]) \\
 &= 1532 / (68 \times 5.6) \\
 &\approx 4.0 \text{ MHz (Note 2)}
 \end{aligned}$$

Note 2: The oscillator frequency is a typical value (Ta = 25°C). Set the resistance to between 4.7 kΩ and 6.8 kΩ.



**Figure 1**  
**CR Oscillator circuit**

**1.2 How to determine sampling frequency (fs)**

$$\begin{aligned}
 f_s \text{ [kHz]} &= f / 128 \\
 &= 4.0 / 128 \\
 &\approx 32 \text{ kHz}
 \end{aligned}$$

**2. Microphone amps**

The IC incorporates microphone amps with auto level control (ALC).

The microphone amp gain is typically 36dB.

When a signal from 0 to -46dB is input, the ALC circuit can control the output signal level.

Changing the external capacitor connected to the ALC circuit to a resistor sets the ALC circuit to off.

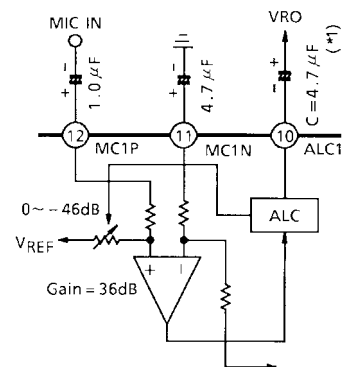
Figure 2 shows the microphone amp circuit.

When C = 4.7 μF, the attack and release times are as follows:

Attack time = Approx. 29 ms  
Release time = Approx. 1.6 s

Setting the capacitance (C) to a smaller value enables the attack and release times to be adjusted. When the ALC circuit is not used, change the capacitor (\*1) to a resistor (approx. 10 kΩ), and connect to GND line.

At power on, while the capacitor is being charged, no sound is output. So, use a capacitance of 4.7 μF or less.



**Figure 2**  
**Microphone amp with ALC**

**3. AD/DA converter and digital delay circuit**

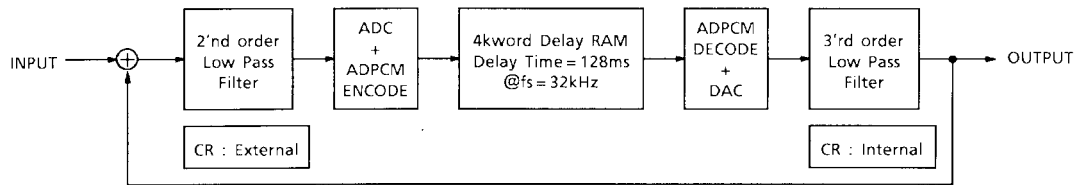
The AD/DA converter is a 12-bit successive comparison type. The sampling frequency when the system clock operates at 4 MHz is 32 kHz.

The analog signal input from the AD converter is converted to 12-bit digital data. The digital delay circuit compresses the 12-bit signal to 4-bit, writes it to delay RAM, then reads it. The 4-bit data read from delay RAM is de-compressed to 12-bit. The 12-bit data are converted to analog signals by the DA converter and output.

The area for delay RAM memory is 4096 words × 4 bits.

The echo delay time is 4096 words × (1/32 kHz) = 128 ms.

Figure 3 is a block diagram of the echo circuit.



**Figure 3 Block diagram of echo circuit**

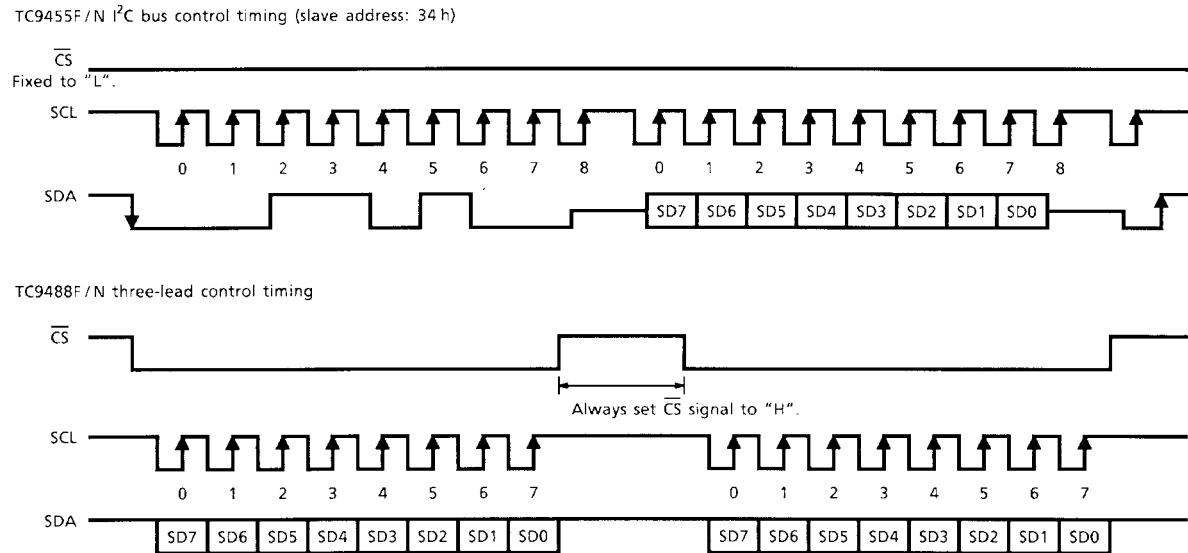
**4. Electronic volume controllers**

The IC incorporates microphone input 1 (MIC1) and microphone input 2 (MIC2) volume and echo volume controllers. The built-in volume controller operates in 16 steps. Using an external variable resistor, volume can be controlled by the DC level or from the MCU using serial data.

The TC9455F/N supports an I<sup>2</sup>C bus interface; the TC9488F/N, a three-lead interface.

**4.1 Serial control timing**

Figure 4 shows the serial control timing.



**Figure 4 Serial control timing**

Table 1 lists bits used to set the volume.

**Table 1 Volume setting bits**

| MODE               | DA7 | DA6 | DA5 | DA4 | DA3 | DA2 | DA1 | DA0 |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| VOL1 setting       | M3  | M2  | M1  | M0  | 0   | 0   | 0   | 0   |
| VOL2 setting       | M3  | M2  | M1  | M0  | 0   | 1   | 0   | 0   |
| VOL3 setting       | M3  | M2  | M1  | M0  | 1   | 0   | 0   | 0   |
| VOL1, 2, 3 setting | M3  | M2  | M1  | M0  | 1   | 1   | 0   | 0   |

M3, M2, M1, M0: Volume setting data

**4.2 Setting of microphone and echo volumes**

Table 2 lists the microphone setting values and attenuation; Table 3 lists the echo volume setting values and attenuation. The DC level settings are typical values.

**Table 2 Microphone volume (VOL1, VOL2) attenuation**

| DC Level Setting (V) | Serial Data Setting |    |    |    | Attenuation (dB) |
|----------------------|---------------------|----|----|----|------------------|
|                      | M3                  | M2 | M1 | M0 |                  |
| 5.0                  | 0                   | 0  | 0  | 0  | 0                |
| 4.4                  | 0                   | 0  | 0  | 1  | -2               |
| 4.2                  | 0                   | 0  | 1  | 0  | -4               |
| 3.9                  | 0                   | 0  | 1  | 1  | -6               |
| 3.7                  | 0                   | 1  | 0  | 0  | -8               |
| 3.5                  | 0                   | 1  | 0  | 1  | -10              |
| 3.2                  | 0                   | 1  | 1  | 0  | -12              |
| 3.0                  | 0                   | 1  | 1  | 1  | -14              |
| 2.7                  | 1                   | 0  | 0  | 0  | -16              |
| 2.5                  | 1                   | 0  | 0  | 1  | -18              |
| 2.3                  | 1                   | 0  | 1  | 0  | -20              |
| 2.0                  | 1                   | 0  | 1  | 1  | -22              |
| 1.8                  | 1                   | 1  | 0  | 0  | -24              |
| 1.5                  | 1                   | 1  | 0  | 1  | -26              |
| 1.3                  | 1                   | 1  | 1  | 0  | -28              |
| 1.1                  | 1                   | 1  | 1  | 1  | -∞               |
| 0.0                  |                     |    |    |    |                  |

**Table 3 Echo volume (VOL3) attenuation**

| DC Level Setting (V) | Serial Data Setting |    |    |    | Attenuation (dB) |
|----------------------|---------------------|----|----|----|------------------|
|                      | M3                  | M2 | M1 | M0 |                  |
| 5.0                  | 0                   | 0  | 0  | 0  | 0                |
| 4.4                  | 0                   | 0  | 0  | 1  | -1               |
| 4.2                  | 0                   | 0  | 1  | 0  | -2               |
| 3.9                  | 0                   | 0  | 1  | 1  | -3               |
| 3.7                  | 0                   | 1  | 0  | 0  | -4               |
| 3.5                  | 0                   | 1  | 0  | 1  | -5               |
| 3.2                  | 0                   | 1  | 1  | 0  | -6               |
| 3.0                  | 0                   | 1  | 1  | 1  | -7               |
| 2.7                  | 1                   | 0  | 0  | 0  | -8               |
| 2.5                  | 1                   | 0  | 0  | 1  | -9               |
| 2.3                  | 1                   | 0  | 1  | 0  | -10              |
| 2.0                  | 1                   | 0  | 1  | 1  | -11              |
| 1.8                  | 1                   | 1  | 0  | 0  | -12              |
| 1.5                  | 1                   | 1  | 0  | 1  | -13              |
| 1.3                  | 1                   | 1  | 1  | 0  | -14              |
| 1.1                  | 1                   | 1  | 1  | 1  | -∞               |
| 0.0                  |                     |    |    |    |                  |

## Maximum Ratings (Ta = 25°C)

| Characteristics       | Symbol           | Rating                     | Unit |
|-----------------------|------------------|----------------------------|------|
| Supply voltage        | V <sub>DD</sub>  | -0.3~6.0                   | V    |
| Input voltage         | V <sub>in</sub>  | -0.3~V <sub>DD</sub> + 0.3 | V    |
| Power dissipation     | P <sub>D</sub>   | TC9455/88F                 | 200  |
|                       |                  | TC9455/88N                 | 300  |
| Operating temperature | T <sub>opr</sub> | -25~85                     | °C   |
| Storage temperature   | T <sub>stg</sub> | -55~150                    | °C   |

## Electrical Characteristics (unless otherwise specified, Ta = 25°C, V<sub>DD</sub> = 5.0 V)

### DC characteristics

| Characteristics          | Symbol           | Test Circuit    | Test Condition   | Min                   | Typ. | Max                   | Unit |
|--------------------------|------------------|-----------------|------------------|-----------------------|------|-----------------------|------|
| Operating supply voltage | V <sub>DD</sub>  | —               | Ta = -25~85°C    | 4.5                   | 5.0  | 5.5                   | V    |
| Operating supply current | I <sub>DD</sub>  | —               | Fmck = 4 MHz     | —                     | 20   | 30                    | mA   |
| Operating frequency      | Fmck             | —               | fs = 32 kHz typ. | —                     | 4.0  | —                     | MHz  |
| Power-on reset voltage   | V <sub>por</sub> | —               |                  | —                     | 4.0  | 4.25                  | V    |
| Input voltage            | "H" level        | V <sub>IH</sub> | —                | V <sub>DD</sub> × 0.8 | —    | V <sub>DD</sub>       | V    |
|                          | "L" level        | V <sub>IL</sub> | —                | 0                     | —    | V <sub>DD</sub> × 0.2 |      |
| Input current            | "H" level        | I <sub>IH</sub> | —                | —                     | —    | 1.0                   | μA   |
|                          | "L" level        | I <sub>IL</sub> | —                | -1.0                  | —    | —                     |      |

### Volume control (when VOLST = "L")

| Characteristics         | Symbol | Test Circuit | Test Condition | Min  | Typ. | Max | Unit |
|-------------------------|--------|--------------|----------------|------|------|-----|------|
| Hysteresis voltage      | VH     | —            |                | —    | 0.12 | —   | V    |
| Input step width        | VST    | —            |                | —    | 0.26 | —   | V    |
| Min level input voltage | Vlmin  | —            |                | —    | 1.1  | 0.8 | V    |
| Max level input voltage | Vlmax  | —            |                | 4.95 | 4.8  | —   | V    |



## AC Characteristics

### Microphone amps and volumes

| Characteristics                   | Symbol           | Test Circuit | Test Condition  | Min                  | Typ.  | Max  | Unit |    |
|-----------------------------------|------------------|--------------|---|----------------------|-------|------|------|----|
| Microphone amp gain               | MICG             | —            | Input 1-kHz sine wave, -50dBV, MCO pin measured.                                  | 47.5                 | 49.5  | 51.5 | dBV  |    |
| MCO Output at ALC Operation       | VM               | —            | Input 1-kHz sine wave, -25dBV.  | -0.8                 | 1.7   | 3.2  | dBV  |    |
| Maximum Input at No ALC Operation | VL               | —            | Input 1-kHz sine wave.  | —                    | -47.5 | —    | dBV  |    |
| Maximum Input 1 at ALC Operation  | VA1              | —            | Input 1-kHz sine wave. MCO output clip limit value at max volume                  | —                    | -4.0  | —    | dBV  |    |
| Maximum Input 2 at ALC Operation  | VA2              | —            | Input 1-kHz sine wave. MCO output clip limit value at microphone amp output point | —                    | 6.5   | —    | dBV  |    |
| POOUT output noise 1              | NO1              | —            | VOL1~3: min   | —                    | -90   | -85  | dBV  |    |
| POOUT output noise 2              | NO2              | —            | VOL1: max, VOL2: min, VOL3: min   | —                    | -63   | -58  | dBV  |    |
| POOUT output noise 3              | NO3              | —            | VOL1: min, VOL2: max, VOL3: min   | —                    | -64   | -59  | dBV  |    |
| POOUT output noise 4              | NO4              | —            | VOL1: min, VOL2: min, VOL3: max   | —                    | -65   | -54  | dBV  |    |
| POOUT output noise 5              | NO5              | —            | VOL1: max, VOL2: max, VOL3: min   | —                    | -60   | -54  | dBV  |    |
| POOUT output noise 6              | NO6              | —            | VOL1: max, VOL2: min, VOL3: min   | —                    | -62   | -54  | dBV  |    |
| POOUT output noise 7              | NO7              | —            | VOL1: min, VOL2: max, VOL3: max   | —                    | -62   | -54  | dBV  |    |
| POOUT output noise 8              | NO8              | —            | VOL1~3: max   | —                    | -59   | -52  | dBV  |    |
| Volume 1, 2 attenuation           | ATT1             | —            | Ratio with one level higher (excluding the minimum level)                         | —                    | -2.0  | —    | dB   |    |
| Volume 3 attenuation              | ATT2             | —            | Ratio with one level higher (excluding the minimum level)                         | —                    | -1.0  | —    | dB   |    |
| Attack time                       | T <sub>ATK</sub> | —            | 1 kHz Sine wave input, -20dBV → -10dBV  | C = 47 μF (Note 3)   | —     | 120  | —    | ms |
|                                   |                  |              |   | C = 0.47 μF (Note 3) | —     | 10   | —    |    |
| Release time                      | T <sub>RLS</sub> | —            | 1 kHz Sine wave input, -10dBV → -20dBV  | C = 47 μF (Note 3)   | —     | 1.6  | —    | s  |
|                                   |                  |              |   | C = 0.47 μF (Note 3) | —     | 0.15 | —    |    |

Note 3: External capacitor of ALC pin

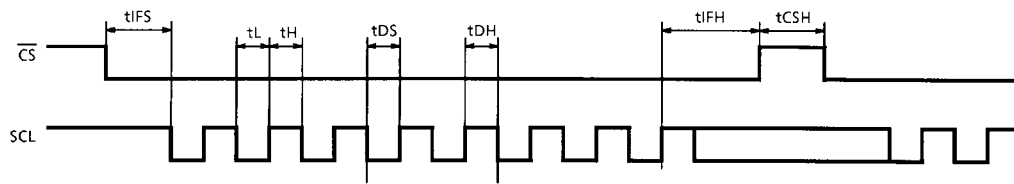
### Microcontroller interface (when VOLST = "H")

| Characteristics                     | Symbol | Test Circuit | Test Condition | Min  | Typ. | Max | Unit |
|-------------------------------------|--------|--------------|----------------|------|------|-----|------|
| Interface setup time                | tIFS   | —            | (Note 4)       | 0.25 | —    | —   | μs   |
| Shift clock "L" duration            | tL     | —            |                | 0.25 | —    | —   | μs   |
| Shift clock "H" duration            | tH     | —            |                | 0.25 | —    | —   | μs   |
| Data setup time                     | tDS    | —            |                | 0.25 | —    | —   | μs   |
| Data hold time                      | tDH    | —            |                | 0.25 | —    | —   | μs   |
| Interface hold time                 | tIFH   | —            | (Note 4)       | 1.0  | —    | —   | μs   |
| $\overline{\text{CS}}$ "H" duration | tCSH   | —            | (Note 4)       | 0.25 | —    | —   | μs   |

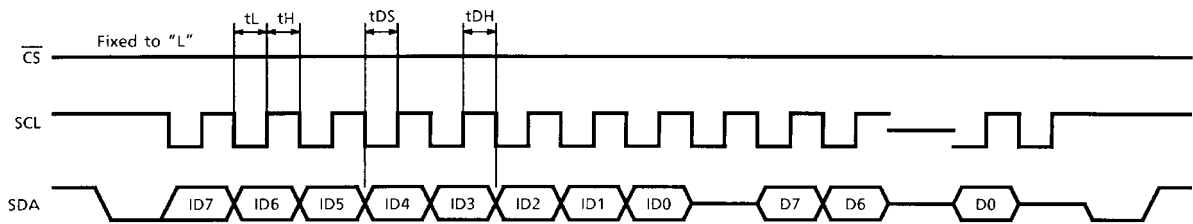
Note 4: With TC9488F and TC9488N

**AC Characteristics Test Points**

**1. TC9488F/N three-lead interface**



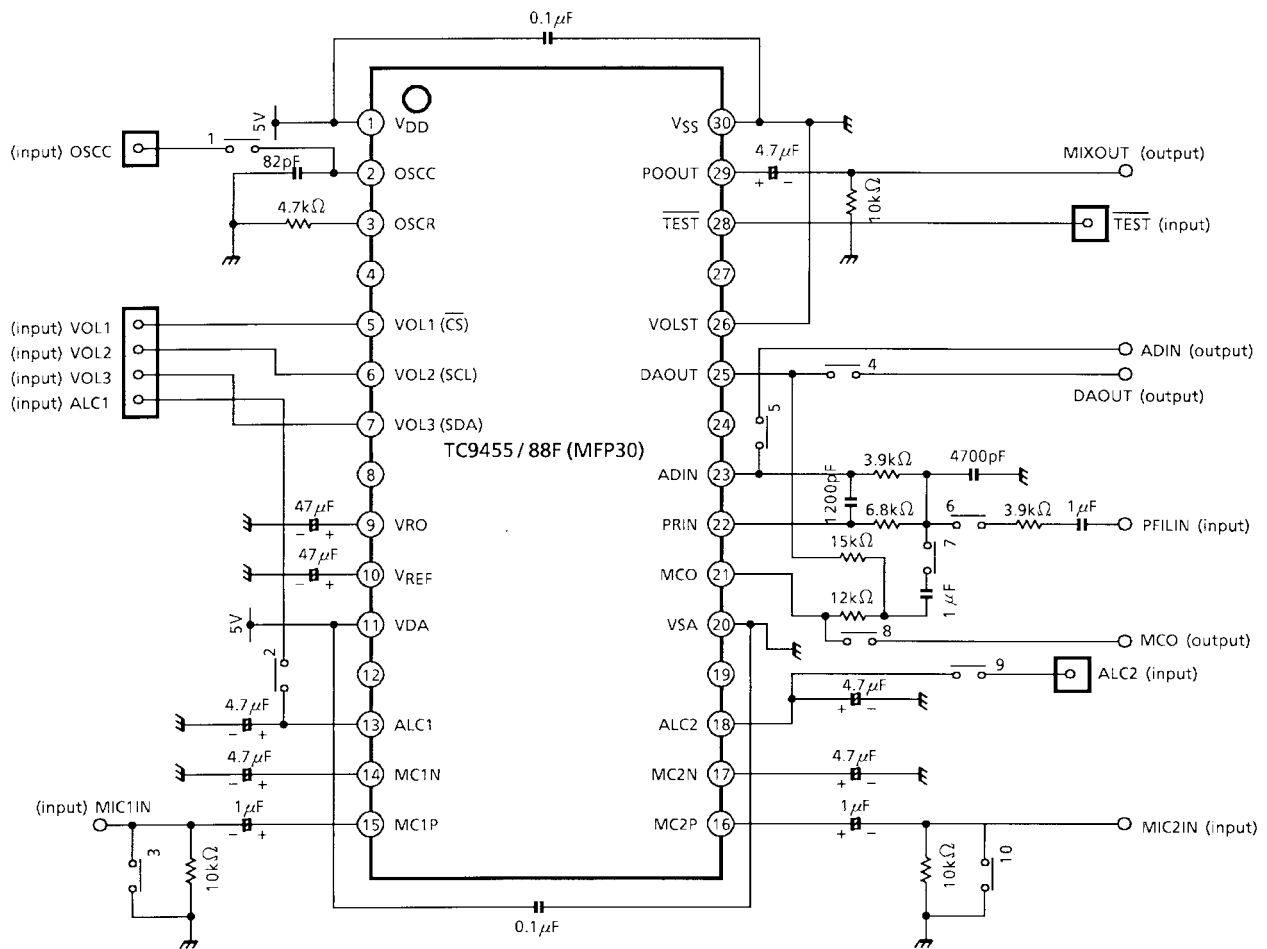
**2. TC9455F/N I<sup>2</sup>C bus interface**



Purchase of TOSHIBA I<sup>2</sup>C components conveys a license under the Phillips I<sup>2</sup>C Patent Right to use the components in an I<sup>2</sup>C system, provided that the system conforms to the I<sup>2</sup>C Standard Specification as defined by Phillips.

- tIFS > 0.25 μs interface setup time
- tL > 0.25 μs shift clock L time
- tH > 0.25 μs shift clock H time
- tDS > 0.25 μs data setup time
- tDH > 0.25 μs data hold time
- tIFH > 1.0 μs interface hold time
- tCSH > 0.25 μs CS signal H duration

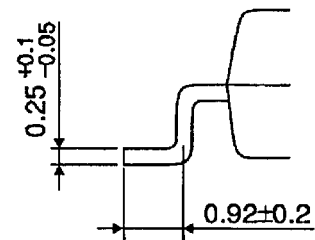
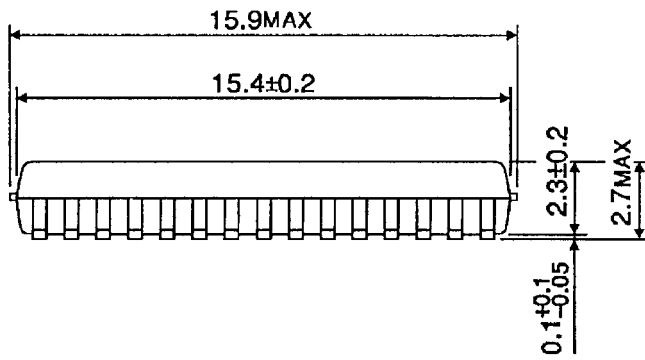
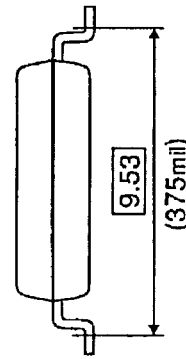
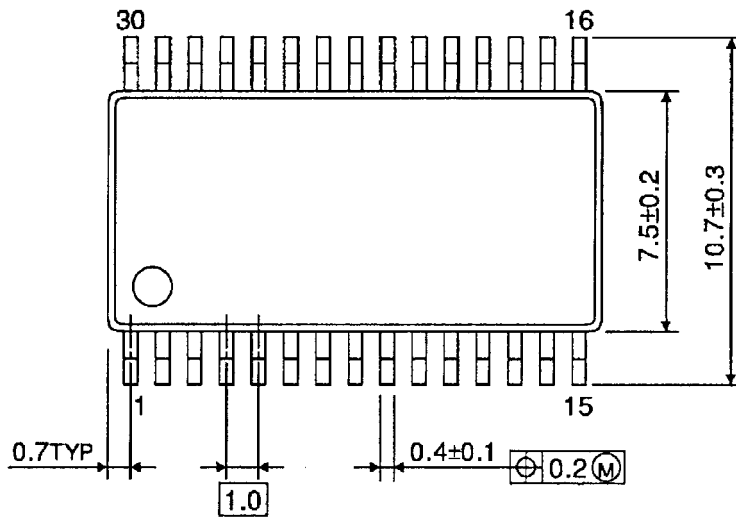
**TC9455/88F AC Test Circuit**



**Package Dimensions**

SSOP30-P-375-1.00

Unit : mm

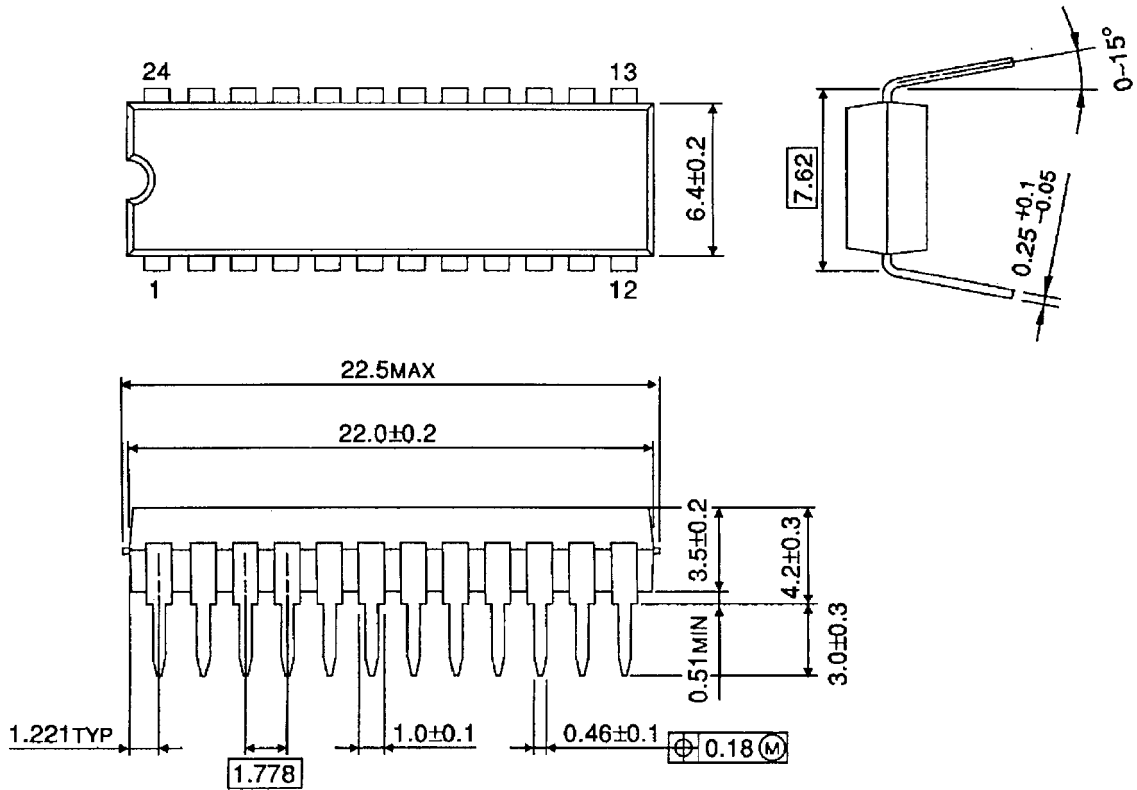


Weight: 1.08 g (typ.)

## Package Dimensions

SDIP24-P-300-1.78

Unit : mm



Weight: 1.2 g (typ.)

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000707EBA

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