

# TC9400F, TC9400N

## $\Sigma$ - $\Delta$ MODULATION SYSTEM DA CONVERTER WITH A BUILT-IN 8-TIMES OVER SAMPLING DIGITAL FILTER / DIGITAL ATTENUATOR

The TC9400F and TC9400N are a 2<sup>nd</sup> order  $\Sigma$ - $\Delta$  modulation system 1-bit DA converter incorporating an 8-times oversampling FIR type digital filter and digital attenuator developed for digital audio equipment. Because the IC is small package (SSOP24, SDIP24) and the de-emphasis filter has been incorporation, it is possible to constitute reducing the size and cost of the DA converter.

### FEATURES

- Built-in 8-times over sampling FIR type digital filter
- DA converter over sampling ratio (OSR) : 192 fs
- Built-in digital de-emphasis filter
- In serial control mode, output amplitude can be set in 128 steps of resolution using microcontroller commands
- In parallel control mode, soft mute can be set for the output signal in 128 steps in 20 ms
- Simultaneous outputs Left and Right channel
- Sampling frequency : 44.1 kHz, 32 kHz, 48 kHz
- Support double speed operation
- Built-in digital zero detection output circuit
- Characteristics of the digital filter and DA converter are as follows :

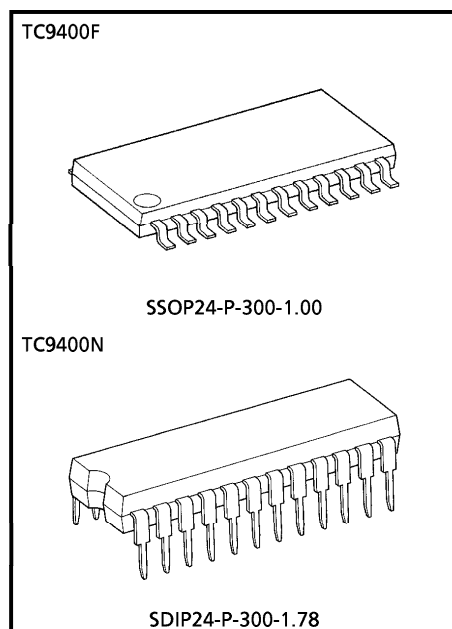
### Digital filter

|                        | DIGITAL FILTER | PASS-BAND RIPPLE | TRANSIENT BAND WIDTH | STOP-BAND SUPPRESSION |
|------------------------|----------------|------------------|----------------------|-----------------------|
| Standard Operation     | 8 fs           | $\pm 0.15$ dB    | 20 k~24.1 kHz        | - 40 dB               |
| Double Speed Operation | 8 fs           | $\pm 0.15$ dB    | 20 k~24.1 kHz        | - 40 dB               |

### DA converter ( $V_{DD} = 5V$ )

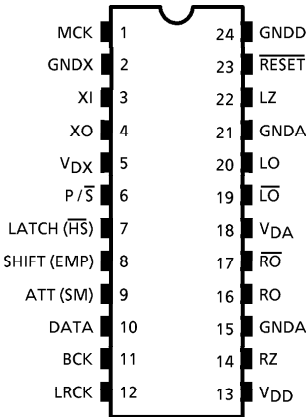
|                        | OSR    | NOISE DISTORTION | S / N RATIO   |
|------------------------|--------|------------------|---------------|
| Standard Operation     | 192 fs | - 90 dB (Typ.)   | 100 dB (Typ.) |
| Double Speed Operation | 192 fs | - 87 dB (Typ.)   | 98 dB (Typ.)  |

- 2 kinds of package, Pin 24 flat package and Pin 24 DIP shrunk package.

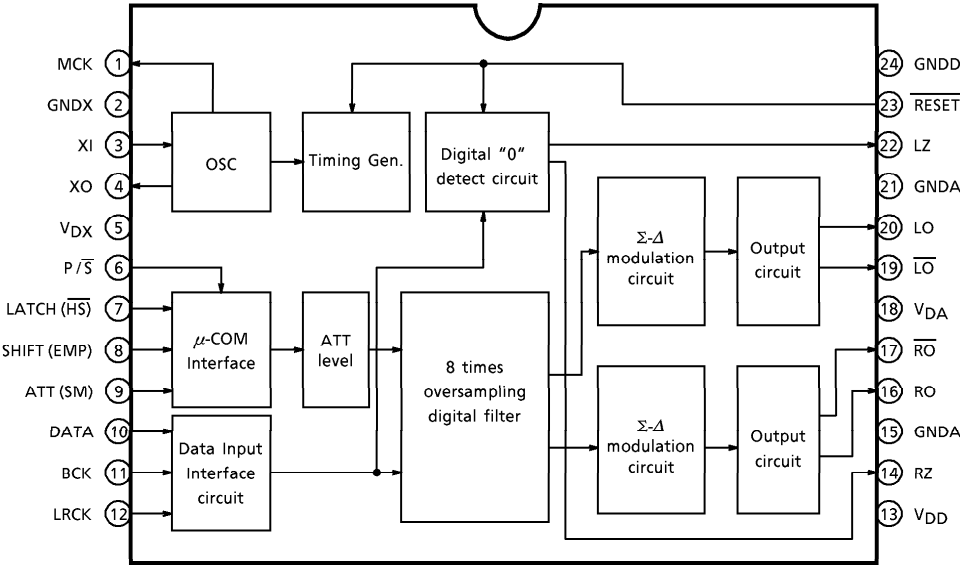


Weight  
 SSOP24-P-300-1.00 : 0.31 g (Typ.)  
 SDIP24-P-300-1.78 : 1.2 g (Typ.)

PIN CONNECTION



BLOCK DIAGRAM



## PIN FUNCTION

| PIN No. | SYMBOL          | I/O | FUNCTION & OPERATION   | REMARKS                           |
|---------|-----------------|-----|--|-----------------------------------|
| 1       | MCK             | O   | System clock output pin  |                                   |
| 2       | GNDX            | —   | Crystal oscillator GND pin   |                                   |
| 3       | XI              | I   | Crystal oscillator connecting pins.<br>Generate the clock required by the system.                        |                                   |
| 4       | XO              | O   |  |                                   |
| 5       | V <sub>DX</sub> | —   | Crystal oscillator power supply pin  |                                   |
| 6       | P/ $\bar{S}$    | I   | Parallel/serial mode select pin  | Shumitt input<br>Pull-up resistor |
| 7       | LATCH<br>(HS)   | I   | Serial mode : Data latch signal input pin<br>Parallel mode : Standard/Double speed operation control pin | Shumitt input<br>Pull-up resistor |
| 8       | SHIFT<br>(EMP)  | I   | Serial mode : Shift clock input pin<br>Parallel mode : De-emphasis filter ON/OFF control pin             | Shumitt input<br>Pull-up resistor |
| 9       | ATT<br>(SM)     | I   | Serial mode : Data input pin<br>Parallel mode : Soft mute control pin                                    | Shumitt input<br>Pull-up resistor |
| 10      | DATA            | I   | Audio data input pin   | Shumitt input                     |
| 11      | BCK             | I   | Bit clock input pin  | Shumitt Input                     |
| 12      | IRCK            | I   | IR clock input pin   | Shumitt input                     |

## MAXIMUM RATINGS (Ta = 25°C)

| CHARACTERISTIC        |         | SYMBOL           | RATING                     | UNIT |
|-----------------------|---------|------------------|----------------------------|------|
| Power Supply Voltage  |         | V <sub>DD</sub>  | -0.3~6.0                   | V    |
|                       |         | V <sub>DA</sub>  | -0.3~6.0                   |      |
|                       |         | V <sub>DX</sub>  | -0.3~6.0                   |      |
| Input Voltage         |         | V <sub>in</sub>  | -0.3~V <sub>DD</sub> + 0.3 | V    |
| Power Dissipation     | TC9400F | PD               | 200                        | mW   |
|                       | TC9400N |                  | 300                        |      |
| Operating Temperature |         | T <sub>opr</sub> | -35~85                     | °C   |
| Storage Temperature   |         | T <sub>stg</sub> | -55~150                    | °C   |

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C V<sub>DD</sub> = V<sub>DX</sub> = V<sub>DA</sub> = 5 V)

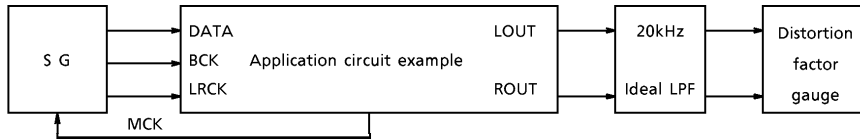
## DC CHARACTERISTICS

| CHARACTERISTIC       |           | SYMBOL          | TEST CIR-CUIT | TEST CONDITION | MIN                   | TYP. | MAX                   | UNIT |
|----------------------|-----------|-----------------|---------------|----------------|-----------------------|------|-----------------------|------|
| Power Supply Voltage |           | V <sub>DD</sub> | —             | Ta = -35~85°C  | 4.5                   | 5.0  | 5.5                   | V    |
|                      |           | V <sub>DX</sub> |               |                | 4.5                   | 5.0  | 5.5                   |      |
|                      |           | V <sub>DA</sub> |               |                | 4.5                   | 5.0  | 5.5                   |      |
| Power Dissipation    |           | I <sub>DD</sub> | —             | XI = 16.9 MHz  | —                     | 30   | 40                    | mA   |
| Input Voltage        | "H" Level | V <sub>IH</sub> | —             |                | V <sub>DD</sub> × 0.7 | —    | V <sub>DD</sub>       | V    |
|                      | "L" Level | V <sub>IL</sub> |               |                | 0                     | —    | V <sub>DD</sub> × 0.3 |      |
| Input Current        | "H" Level | I <sub>IH</sub> | —             |                | -10                   | —    | 10                    | μA   |
|                      | "L" Level | I <sub>IL</sub> |               |                |                       |      |                       |      |

## AC CHARACTERISTICS

| CHARACTERISTIC      |                  | SYMBOL           | TEST CIR-CUIT | TEST CONDITION                           | MIN | TYP.    | MAX  | UNIT |
|---------------------|------------------|------------------|---------------|--|-----|---------|------|------|
| Noise Distortion    |                  | THD + N          | 1             | 1 kHz Sine wave, full-scale input        | —   | -90     | -80  | dB   |
| S/N Ratio           |                  | S/N              | 1             |  | 90  | 100     | —    | dB   |
| Dynamic Range       |                  | DR               | 1             | 1 kHz Sine wave,<br>-60 Input conversion | 90  | 95      | —    | dB   |
| Cross-talk          |                  | CT               | 1             | 1 kHz Sine wave, full-scale input        | —   | -95     | -90  | dB   |
| Operating Frequency |                  | f <sub>opr</sub> | —             |  | 12  | 16.9344 | 18.5 | MHz  |
| Input Frequency     | f <sub>LR</sub>  | —                | —             | LRCK duty cycle = 50%                    | 30  | 44.1    | 100  | kHz  |
|                     | f <sub>BCK</sub> | —                |               | BCK duty cycle = 50%                     | 1.0 | 2.1168  | 6.2  |      |
| Rise Time           |                  | t <sub>r</sub>   | —             | LRCK, BCK (10~90%)                       | —   | —       | 15   | nS   |
| Fall Time           |                  | t <sub>f</sub>   |               |  |     |         |      |      |
| Delay Time          |                  | t <sub>d</sub>   | —             | BCK ↓ Edge → LRCK, DATA                  | -50 | —       | 50   | nS   |

- TEST CIRCUIT-1 : With the use of a sample application circuit

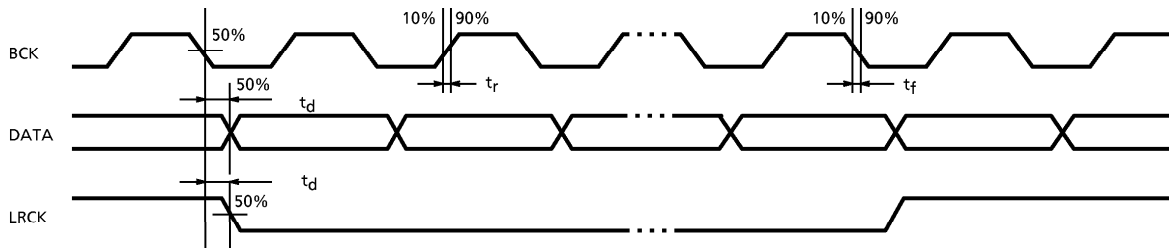


SG : ANRITSU : MG-22A or equivalent  
 LPF : SHIBASOKU : 725C internal filter  
 DISTORTION : SHIBASOKU : 725C or equivalent

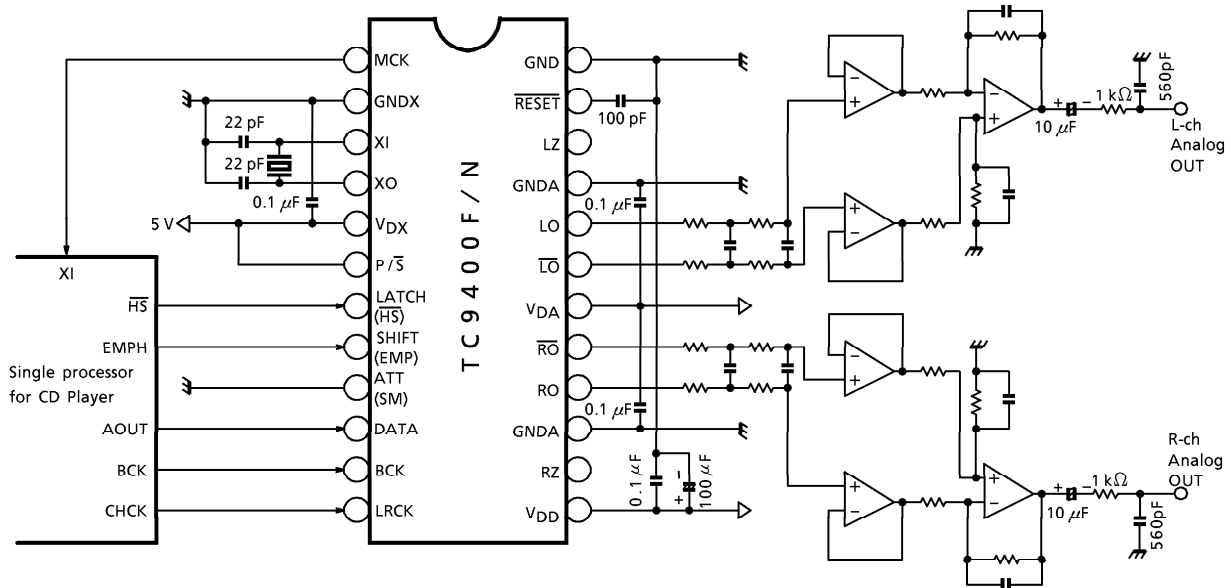
| MEASURING ITEM | DISTORTION FACTOR GAUGE<br>FILTER SETTING A WEIGHT |
|----------------|--|
| THD + N, CT    | OFF  |
| S/N, DR        | ON   |

A weight : IEC-A or equivalent

- AC CHARACTERISTICS STIPULATED POINT : (Input signal stipulation : LRCK, BCK, DATA)

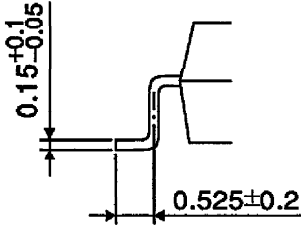
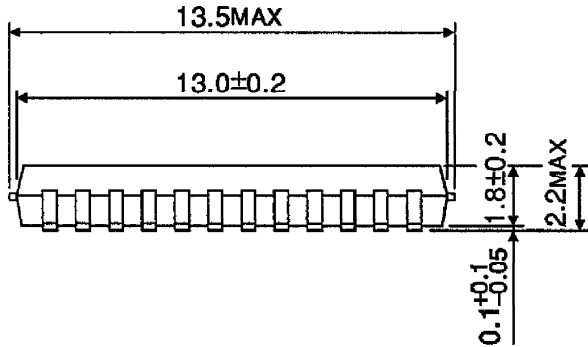
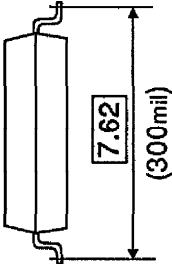
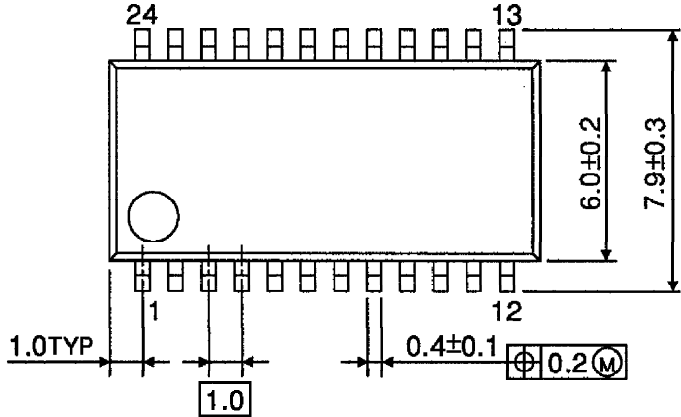


Application Circuit Example



PACKAGE DIMENSIONS  
SSOP24-P-300-1.00

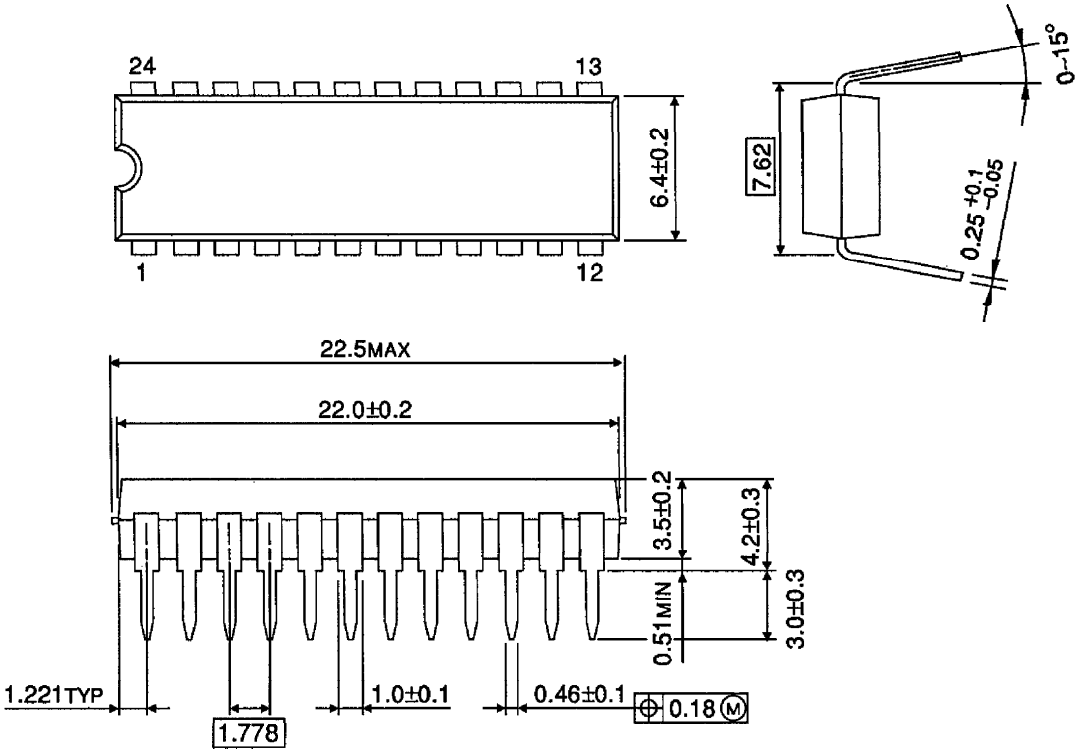
Unit : mm



Weight : 0.31 g (Typ.)

PACKAGE DIMENSIONS  
SDIP24-P-300-1.78

Unit : mm



Weight : 1.2 g (Typ.)

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