

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

# TC9198P, TC9198F

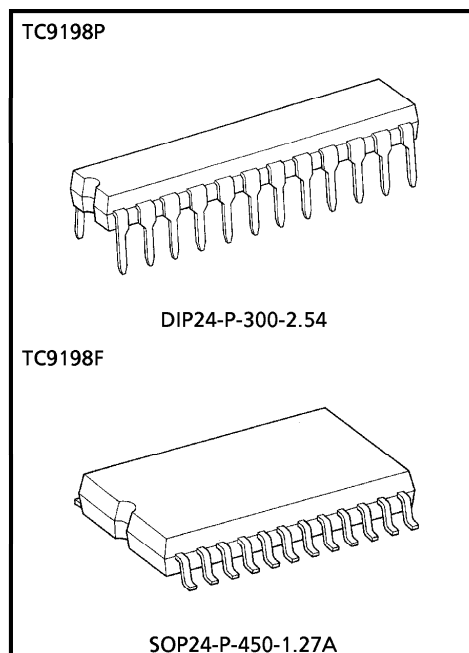
## PROGRAMMABLE COUNTER

TC9198P, TC9198F are high speed programmable counters developed for dividing PLL circuits and other various circuits.

### FEATURES

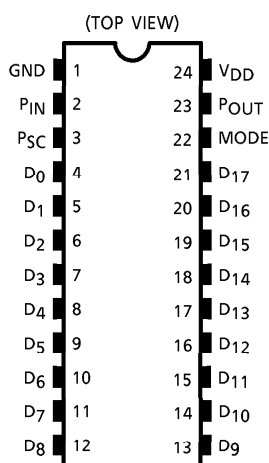
- Setting of number of divisions can be made directly from the input terminals.
- The counter allows changing-over of swallow system / simple division.
- At simple division, changing-over of BCD code / BINARY code can be performed.
- The number of division is 262, 143 in maximum in swallow mode, and can be 5 to 65,535 at BINARY in simple division mode and can be 5 to 15,999 at BCD code.
- Owing to CMOS construction, the operating power voltage range is wide, and the power consumption is low.
- The package is DIP-24PIN for TC9198P and SOP-24PIN for TC9198F.

### PIN CONNECTION



### Weight

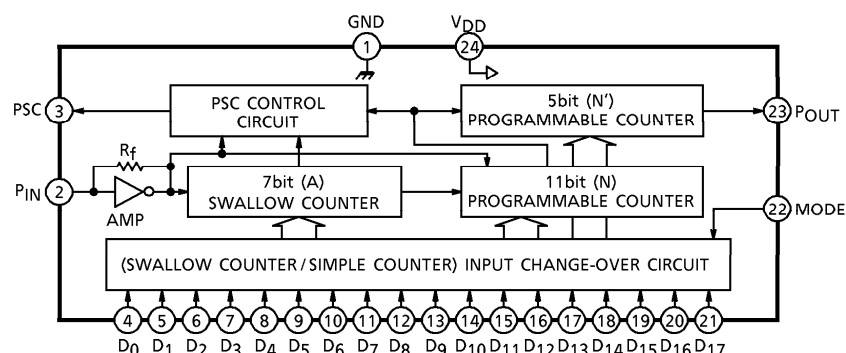
DIP24-P-300-2.54 : 1.2g (Typ.)  
SOP24-P-450-1.27A : 0.48g (Typ.)



980910EBA2

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## BLOCK DIAGRAM



## PIN FUNCTION

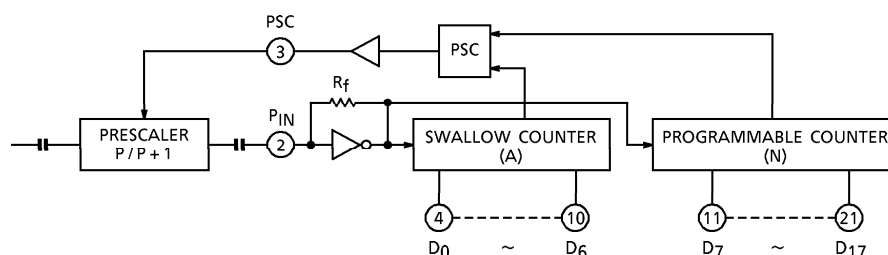
| PIN No. | SYMBOL           | PIN NAME                             | FUNCTION AND OPERATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | NOTE                          |
|---------|------------------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| 1       | GND              | Ground Terminal                      | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | —                             |
| 24      | V <sub>DD</sub>  | Power Supply Terminal                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 2       | P <sub>IN</sub>  | Programmable Counter Input           | Programmable counter input terminal. Prescaler output is input by the capacitor coupling.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Amp. Circuit built in         |
| 3       | PSC              | Prescaler Control Output             | No. of division control signal output prescaler. It becomes P in "H" level, and P + 1 in "L" level.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | —                             |
| 22      | MODE             | Counter Operation Change-over Input  | Change-over input for swallow counter operation and simple counter operation. It becomes swallow counter at "L" level, or open and simple counter operation at "H" level.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Pull down resistance built in |
| 4       | D <sub>0</sub>   | Number of Division Setting Input     | Input terminal for setting number of division of programmable counter.<br>(1) MODE (22PIN) = at "L" level <ul style="list-style-type: none"><li>D<sub>0</sub>~D<sub>6</sub>→Swallow counter : A</li><li>D<sub>7</sub>~D<sub>17</sub>→Programmable counter : N</li></ul> (2) MODE = at "H" and D <sub>17</sub> = at "L" level <ul style="list-style-type: none"><li>Simple counter operation in setting BINARY code.</li><li>D<sub>0</sub>~D<sub>15</sub>→Programmable counter : N</li><li>D<sub>16</sub>→NC</li></ul> (3) MODE = at "H" and D <sub>17</sub> = at "H" level <ul style="list-style-type: none"><li>Simple counter operation in setting BCD code.</li><li>D<sub>0</sub>~D<sub>3</sub>→N = 1~9 setting</li><li>D<sub>4</sub>~D<sub>7</sub>→N = 10~90 setting</li><li>D<sub>8</sub>~D<sub>11</sub>→N = 100~900 setting</li><li>D<sub>12</sub>~D<sub>15</sub>→N = 1000~15000 setting</li><li>D<sub>16</sub>→NC</li></ul> |                               |
| 5       | D <sub>1</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 6       | D <sub>2</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 7       | D <sub>3</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 8       | D <sub>4</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 9       | D <sub>5</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 10      | D <sub>6</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 11      | D <sub>7</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 12      | D <sub>8</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 13      | D <sub>9</sub>   |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 14      | D <sub>10</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 15      | D <sub>11</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 16      | D <sub>12</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 17      | D <sub>13</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 18      | D <sub>14</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 19      | D <sub>15</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 20      | D <sub>16</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 21      | D <sub>17</sub>  |                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| 23      | P <sub>OUT</sub> | Programmable Counter Output Terminal | 1/N of P <sub>IN</sub> input frequency is output pulse width corresponds to 4 cycles of input frequency.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | —                             |

## DESCRIPTION ON FUNCTION AND OPERATION

## 1. Programmable counter

When the MODE INPUT (Pin 22) is set to "L" level (or opened), the programmable counter becomes swallow system.

The system consists of a 7bit swallow counter, 11bit programmable counter and a prescaler logic which change-over the number of divisions of the 2-module prescaler connected to the outside.



- Total number of divisions can be determined by the following formula

$$\text{Number of divisions} = (P + 1) \cdot A + P \cdot (N - A)$$

$$= N \cdot P + A$$

Where,  $N > A$

- The prescaler used requires to be the number of divisions of  $P + 1$  when the PSC terminal is in "L" level and of  $P$  when it is in "H" level.
- The input for setting the number of divisions of the programmable counter consists of 18bits, but it should be cared that it changes by the number of divisions  $P$  of the prescaler used. ( $P \leq 128$ )

(1) When prescaler is  $P = 128$

| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> | D <sub>16</sub> | D <sub>17</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2 <sup>0</sup> | 2 <sup>1</sup> | 2 <sup>2</sup> | 2 <sup>3</sup> | 2 <sup>4</sup> | 2 <sup>5</sup> | 2 <sup>6</sup> | 2 <sup>7</sup> | 2 <sup>8</sup> | 2 <sup>9</sup> | 2 <sup>10</sup> | 2 <sup>11</sup> | 2 <sup>12</sup> | 2 <sup>13</sup> | 2 <sup>14</sup> | 2 <sup>15</sup> | 2 <sup>16</sup> | 2 <sup>17</sup> |

(\*) The BINARY code D of the number of division is  $16,384 \leq D \leq 262,143$ , as a rule.

(2) When prescaler is  $P = 64$

| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> | D <sub>16</sub> | D <sub>17</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2 <sup>0</sup> | 2 <sup>1</sup> | 2 <sup>2</sup> | 2 <sup>3</sup> | 2 <sup>4</sup> | 2 <sup>5</sup> | "0"            | 2 <sup>6</sup> | 2 <sup>7</sup> | 2 <sup>8</sup> | 2 <sup>9</sup>  | 2 <sup>10</sup> | 2 <sup>11</sup> | 2 <sup>12</sup> | 2 <sup>13</sup> | 2 <sup>14</sup> | 2 <sup>15</sup> | 2 <sup>16</sup> |

(\*) The BINARY code D of the number of divisions is  $4,096 \leq D \leq 131,071$ , as a rule.

(\*) D<sub>6</sub> (Pin 10) is used as GND or in open.

(3) When prescaler is  $P = 32$

| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> | D <sub>16</sub> | D <sub>17</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2 <sup>0</sup> | 2 <sup>1</sup> | 2 <sup>2</sup> | 2 <sup>3</sup> | 2 <sup>4</sup> | "0"            |                | 2 <sup>5</sup> | 2 <sup>6</sup> | 2 <sup>7</sup> | 2 <sup>8</sup>  | 2 <sup>9</sup>  | 2 <sup>10</sup> | 2 <sup>11</sup> | 2 <sup>12</sup> | 2 <sup>13</sup> | 2 <sup>14</sup> | 2 <sup>15</sup> |

(\*) The BINARY code D of the number of divisions is  $1,024 \leq D \leq 65,535$ , as a rule.

(\*) D<sub>5</sub> (Pin 9) and D<sub>6</sub> (Pin 10) are used as GND or in open.

(4) When prescaler is  $P = 16$

|                |                |                |                |                |                |                |                |                |                |                 |                 |                 |                 |                 |                 |                 |                 |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> | D <sub>16</sub> | D <sub>17</sub> |
| 2 <sup>0</sup> | 2 <sup>1</sup> | 2 <sup>2</sup> | 2 <sup>3</sup> | "0"            |                |                | 2 <sup>4</sup> | 2 <sup>5</sup> | 2 <sup>6</sup> | 2 <sup>7</sup>  | 2 <sup>8</sup>  | 2 <sup>9</sup>  | 2 <sup>10</sup> | 2 <sup>11</sup> | 2 <sup>12</sup> | 2 <sup>13</sup> | 2 <sup>14</sup> |

(\*) The BINARY code D of the number of divisions is  $256 \leq D \leq 32,767$ , as a rule.

(\*) D<sub>4</sub>~D<sub>6</sub> (Pin 8~Pin 9) are used as GND or in open.

## 2. Simple program counter

When the MODE INPUT (Pin 22) is set to "H" level, the simple counter system is established.

When D<sub>17</sub> (Pin 21) is made to "H" level, the system operates in BCD mode, and to "L" level, in BINARY mode.

(1) Operation in BINARY MODE : D<sub>17</sub> (Pin 21) = D<sub>16</sub> (Pin 20) = "L" level or in open

| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2 <sup>0</sup> | 2 <sup>1</sup> | 2 <sup>2</sup> | 2 <sup>3</sup> | 2 <sup>4</sup> | 2 <sup>5</sup> | 2 <sup>6</sup> | 2 <sup>7</sup> | 2 <sup>8</sup> | 2 <sup>9</sup> | 2 <sup>10</sup> | 2 <sup>11</sup> | 2 <sup>12</sup> | 2 <sup>13</sup> | 2 <sup>14</sup> | 2 <sup>15</sup> |

※ The BINARY code D of number of divisions becomes  $5 \leq D \leq 65,535$

(2) Operation in BCD MODE : D<sub>17</sub> (Pin 21) = "H", D<sub>16</sub> (Pin 20) = "L" level or open

| D <sub>0</sub> | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D <sub>4</sub> | D <sub>5</sub> | D <sub>6</sub> | D <sub>7</sub> | D <sub>8</sub> | D <sub>9</sub> | D <sub>10</sub> | D <sub>11</sub> | D <sub>12</sub> | D <sub>13</sub> | D <sub>14</sub> | D <sub>15</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1              | 2              | 4              | 8              | 1              | 2              | 4              | 8              | 1              | 2              | 4               | 8               | 1               | 2               | 4               | 8               |

(\*) D<sub>0</sub>~D<sub>3</sub>, D<sub>4</sub>~D<sub>7</sub>, D<sub>8</sub>~D<sub>11</sub> set number of divisions by BCD code.

It should be cared that it does not operate when it is set  $N = 10$  or more.

(\*) In D<sub>12</sub>~D<sub>15</sub>, the number of division can be set by the BINARY code.

D<sub>12</sub>~D<sub>15</sub> = 0101 (A) →  $N = 10,000$

D<sub>12</sub>~D<sub>15</sub> = 1101 (B) →  $N = 11,000$

D<sub>12</sub>~D<sub>15</sub> = 0011 (C) →  $N = 12,000$

D<sub>12</sub>~D<sub>15</sub> = 1011 (D) →  $N = 13,000$

D<sub>12</sub>~D<sub>15</sub> = 0111 (E) →  $N = 14,000$

D<sub>12</sub>~D<sub>15</sub> = 1111 (F) →  $N = 15,000$

(\*) The BCD code of the number of divisions becomes  $5 \leq D \leq 15,999$

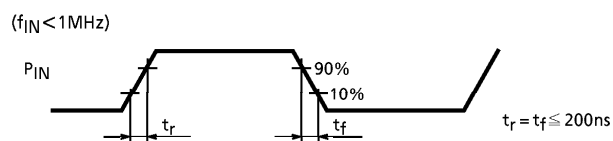
**MAXIMUM RATINGS** ( $T_a = 25^\circ\text{C}$ )

| CHARACTERISTIC        | SYMBOL    | RATING                   | UNIT             |
|-----------------------|-----------|--------------------------|------------------|
| Power Supply Voltage  | $V_{DD}$  | $-0.3 \sim 7.0$          | V                |
| Input Voltage         | $V_{IN}$  | $-0.3 \sim V_{DD} + 0.3$ | V                |
| Power Dissipation     | $P_D$     | 300                      | mW               |
| Operating Temperature | $T_{opr}$ | $-40 \sim 85$            | $^\circ\text{C}$ |
| Storage Temperature   | $T_{stg}$ | $-65 \sim 150$           | $^\circ\text{C}$ |

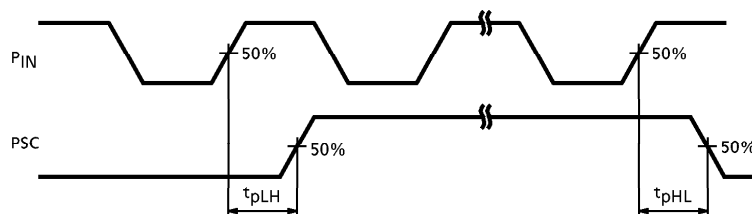
**ELECTRICAL CHARACTERISTICS** (Unless otherwise specified,  $T_a = -40 \sim 85^\circ\text{C}$ ,  $V_{DD} = 5.0\text{V}$ )

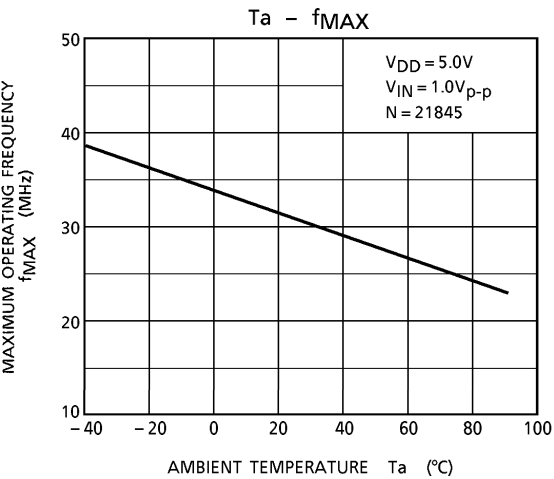
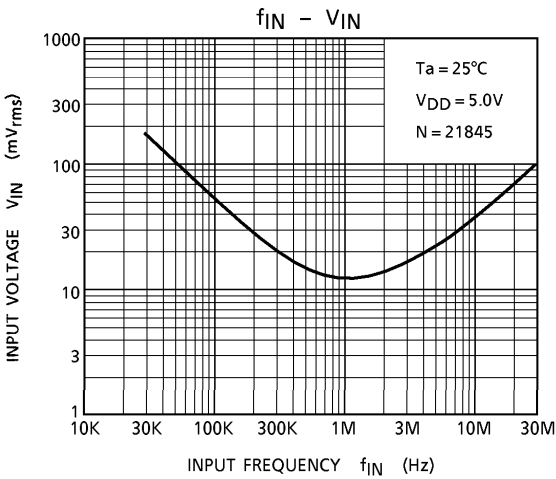
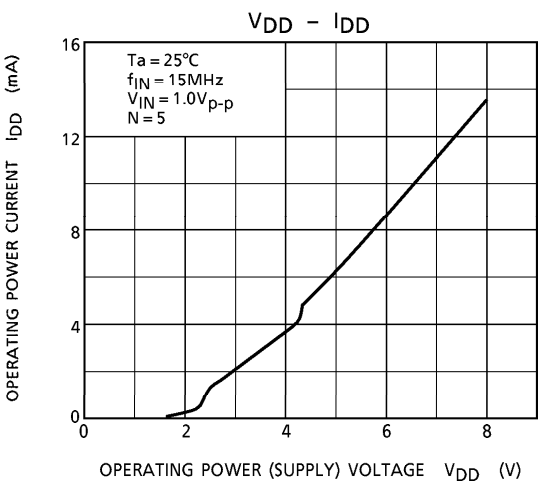
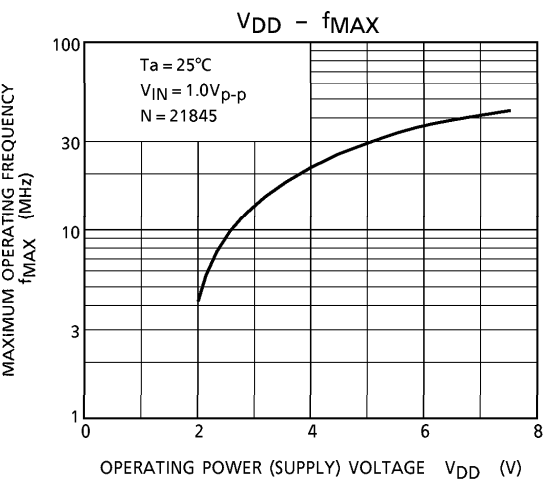
| CHARACTERISTIC              | SYMBOL       | TEST CIRCUIT | TEST CONDITION                                                     | MIN.                   | TYP. | MAX.                | UNIT       |
|-----------------------------|--------------|--------------|--------------------------------------------------------------------|------------------------|------|---------------------|------------|
| Operating Supply Voltage    | $V_{DD}$     | —            | $f_{IN} = 15\text{MHz}$ , $V_{IN} = 1.0\text{V}_{p-p}$             | 4.0                    | 5.0  | 6.0                 | V          |
| Operating Supply Current    | $I_{DD}$     | —            |                                                                    | —                      | 5.0  | 10                  | mA         |
| Maximum Operating Frequency | $f_{opr(1)}$ | —            | $V_{IN} = 1.0\text{V}_{p-p}$ , BINARY mode                         | 1.0                    | —    | 15                  | MHz        |
|                             | $f_{opr(2)}$ | —            | $V_{IN} = 1.0\text{V}_{p-p}$ , BCD mode                            | 1.0                    | —    | 15                  |            |
| Minimum Operating Frequency | $f_{MIN}$    | —            | $V_{IN} = 1.0\text{V}_{p-p}$ (Note 1)                              | —                      | 0.5  | 1.0                 | kHz        |
| Operating Input Amplitude   | $V_{IN}$     | —            | $f_{IN} = 15\text{MHz}$                                            | 1.0                    | ~    | $V_{DD} - 0.1$      | $V_{p-p}$  |
| Input Voltage               | "H" Level    | $V_{IH}$     | D <sub>0</sub> ~D <sub>17</sub> terminal<br>MODE terminal          | $V_{DD} \times 0.7$    | ~    | $V_{DD}$            | V          |
|                             | "L" Level    | $V_{IL}$     |                                                                    | 0                      | ~    | $V_{DD} \times 0.3$ |            |
| Pull-down Resistance        | $R_{DW}$     | —            |                                                                    | 32                     | 47   | 62                  | k $\Omega$ |
| Output Current              | "H" Level    | $I_{OH}$     | PSC, P <sub>OUT</sub> terminal                                     | $V_{OH} = 4.0\text{V}$ | 0.5  | 1.0                 | mA         |
|                             | "L" Level    | $I_{OL}$     |                                                                    | $V_{OL} = 1.0\text{V}$ | 0.5  | 1.0                 |            |
| Input Resistance            | $R_f$        | —            | P <sub>IN</sub> terminal                                           | 82                     | 125  | 250                 | k $\Omega$ |
| Transfer Time               | "H" Level    | $t_{pLH}$    | P <sub>IN</sub> →PSC transfer time<br>$C_L = 15\text{pF}$ (Note 2) | —                      | 100  | 200                 | ns         |
|                             | "L" Level    | $t_{pHL}$    |                                                                    | —                      | 100  | 200                 |            |

(Note 1) At the test of the minimum operating frequency, the input waveform is specified as follows.



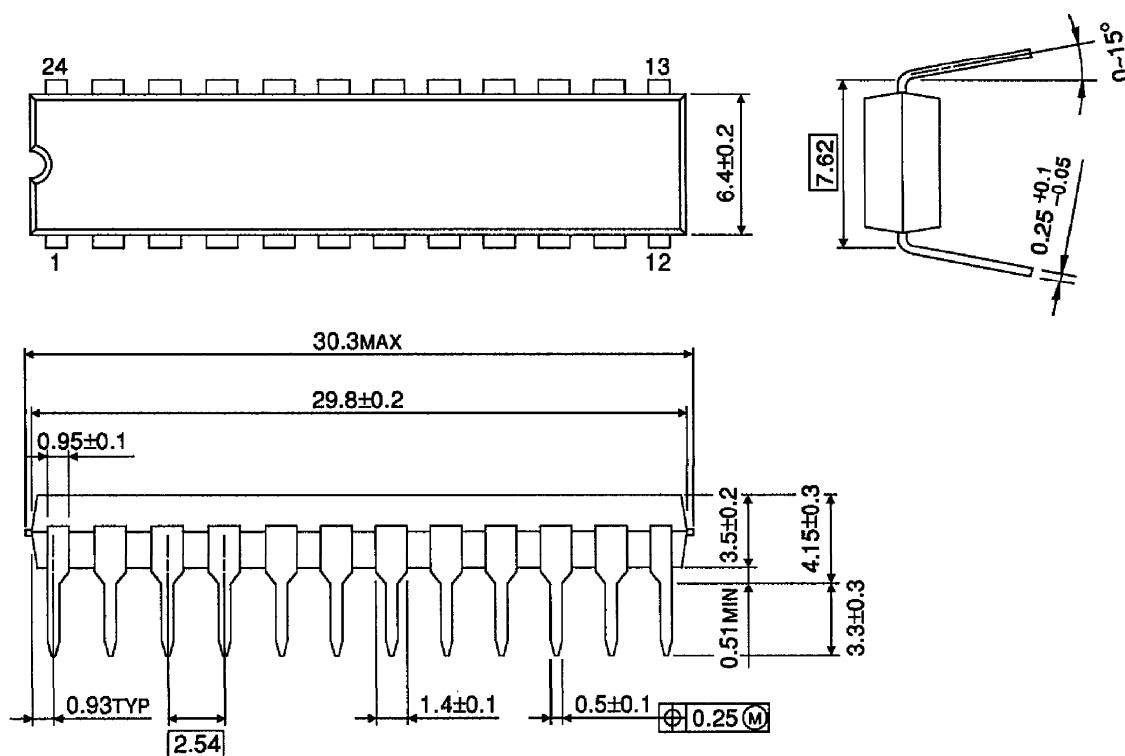
(Note 2) P<sub>IN</sub>→PSC transfer time





**OUTLINE DRAWING**  
DIP24-P-300-2.54

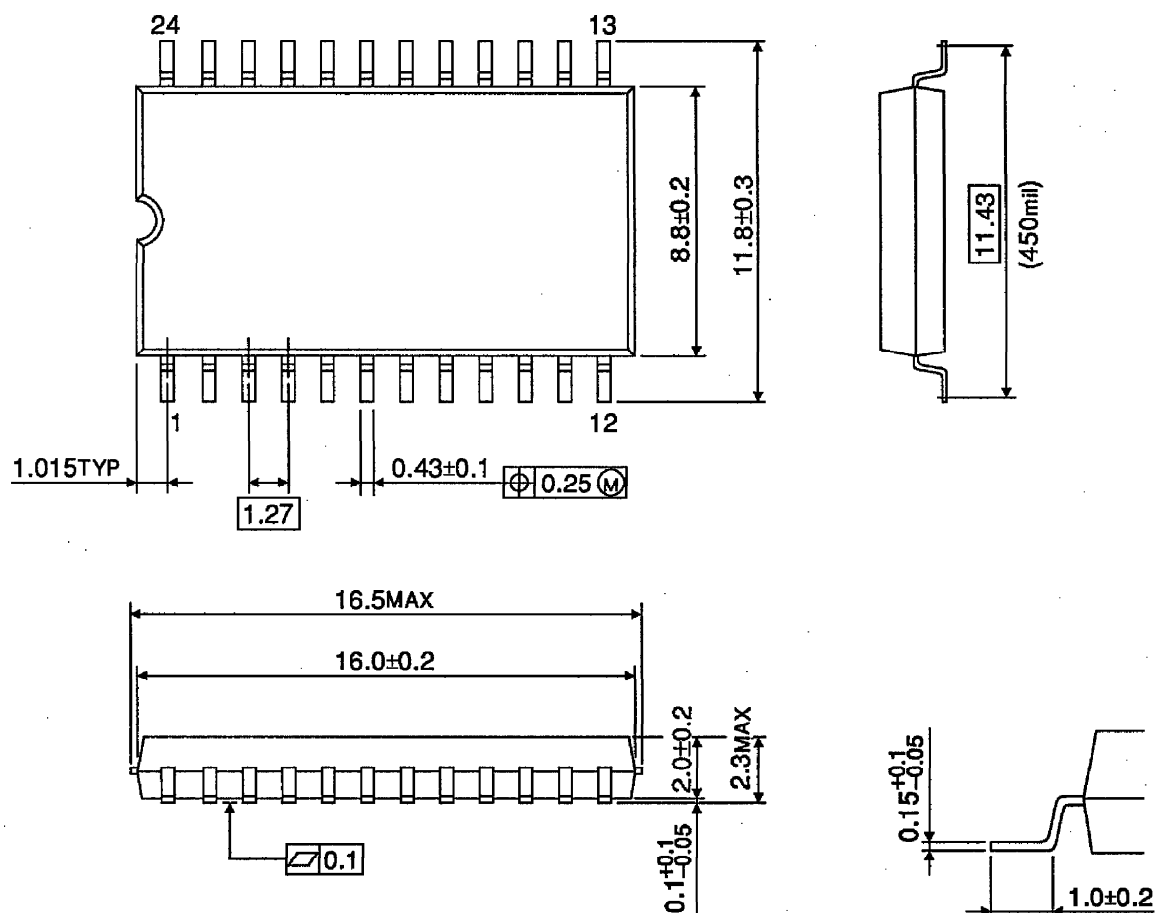
Unit : mm



Weight : 1.2g (Typ.)

**OUTLINE DRAWING**  
SOP24-P-450-1.27A

Unit : mm



Weight : 0.48g (Typ.)