

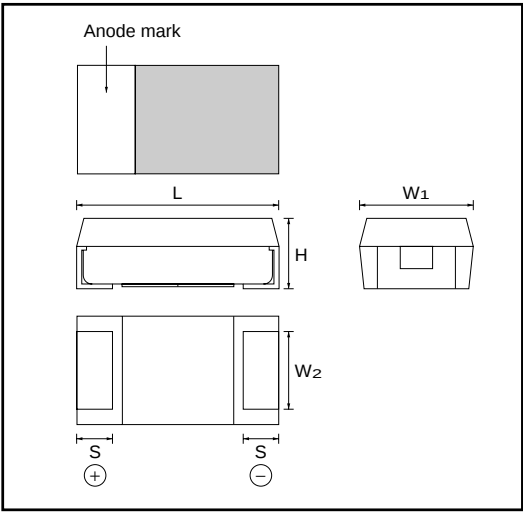
# Chip tantalum capacitors with open-function built-in

## TCFG series P Case

### ●Features

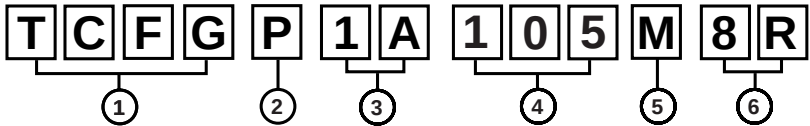
- 1) Safety design by open function built - in.
- 2) Wide capacitance range
- 3) Screening by thermal shock.

### ●External dimensions (Unit : mm)



| Case code | L       | W <sub>1</sub> | W <sub>2</sub> | H        | S        |
|-----------|---------|----------------|----------------|----------|----------|
| P (2012)  | 2.0±0.2 | 1.25±0.2       | 0.9±0.2        | Max.1.20 | 0.45±0.3 |

### ●Product designation



- ① Series name  
TCFG

- ② Case code  
TCFG ..... P

- ③ Rated Voltage

| Rated voltage (V) | 4  | 6.3 | 10 | 16 | 20 | 25 |
|-------------------|----|-----|----|----|----|----|
| CODE              | 0G | 0J  | 1A | 1C | 1D | 1E |

- ④ Capacitance  
Nominal capacitance in pF in 3 digits : 2significant figure representing the number of 0's.

- ⑤ Capacitance tolerance  
M : ±20%    K : ±10%

- ⑥ Taping  
8 : Tape width (8mm)  
R : Positive electrode on the side opposite to sprocket hole

## Tantalum capacitors

## ●Capacitance range

TCFG series P Case

| (μF)      | Rated voltage |           |          |          |          |          |
|-----------|---------------|-----------|----------|----------|----------|----------|
|           | 4<br>0G       | 6.3<br>0J | 10<br>1A | 16<br>1C | 20<br>1D | 25<br>1E |
| 1.0 (105) |               |           | P        | P        | P        | P        |
| 1.5 (155) |               | P         | P        | P        |          |          |
| 2.2 (225) | P             | P         | P        | P        |          |          |
| 3.3 (335) | P             | P         | P        | P        |          |          |
| 4.7 (475) | P             | P         | P        |          |          |          |
| 6.8 (685) | P             | P         |          |          |          |          |
| 10 (106)  | P             | P         |          |          |          |          |
| 15 (156)  | P             | P         |          |          |          |          |
| 22 (226)  | P             |           |          |          |          |          |
| 33 (336)  |               |           |          |          |          |          |
| 47 (476)  |               |           |          |          |          |          |
| 68 (686)  |               |           |          |          |          |          |

Remark) Case size codes (P) in the above show each size products line-up.

## ●Marking

The indications listed below should be given on the surface of a capacitor.

- ① Polarity : The polarity should be shown by □ bar. (on the anode side)
- ② Rated DC voltage : Due to the small size of P case, a voltage code is used as shown below.
- ③ Nominal capacitance

| Voltage Code | Rated DC Voltage (V) |
|--------------|----------------------|
| g            | 4                    |
| j            | 6.3                  |
| A            | 10                   |
| C            | 16                   |
| D            | 20                   |
| E            | 25                   |

| Capacitance Code | Nominal Capacitance (μF) |
|------------------|--------------------------|
| A                | 1.0                      |
| E                | 1.5                      |
| J                | 2.2                      |
| N                | 3.3                      |
| S                | 4.7                      |
| W                | 6.8                      |
| a                | 10                       |
| e                | 15                       |
| j                | 22                       |

Visual typical example (1) voltage code (2) capacitance code

[P Case]      note 1)      j      J  
                                 (1)    (2)



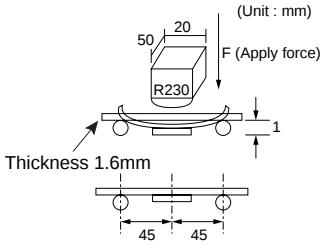
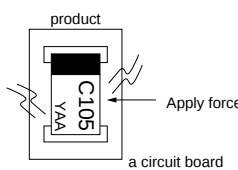
note 2) voltage code and capacitance code are variable with parts number

## Tantalum capacitors

## ●Characteristics

| Item                                                   |            | Performance                                                                           |     |     |    |    |    |  | Test conditions<br>(based on JIS C5101-1 and JIS C5101-3)                                                                                                                                                                                                                       |
|--------------------------------------------------------|------------|---------------------------------------------------------------------------------------|-----|-----|----|----|----|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating Temperature                                  |            | -55 °C to +125 °C                                                                     |     |     |    |    |    |  | Voltage reduction when temperature exceeds +85°C                                                                                                                                                                                                                                |
| Maximum operating temperature with no voltage derating |            | +85 °C                                                                                |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
| Rated Voltage (V.DC)                                   |            | 4                                                                                     | 6.3 | 10  | 16 | 20 | 25 |  | at 85°C                                                                                                                                                                                                                                                                         |
| Category Voltage (V.DC)                                |            | 2.5                                                                                   | 4   | 6.3 | 10 | 13 | 16 |  | at 125°C                                                                                                                                                                                                                                                                        |
| Surge Voltage                                          |            | 5.2                                                                                   | 8   | 13  | 20 | 26 | 32 |  | at 85°C                                                                                                                                                                                                                                                                         |
| DC leakage current                                     |            | 0.5μA or 0.01CV whichever is greater<br>(Shown in "Standard list")                    |     |     |    |    |    |  | As per 4.9 JIS C 5101-1<br>As per 4.5.1 JIS C 5101-3<br>Voltage : Rated voltage for 1 min                                                                                                                                                                                       |
| Capacitance tolerance                                  |            | Shall be satisfied allowance range.<br>±10%, ±20%                                     |     |     |    |    |    |  | As per 4.7 JIS C 5101-1<br>As per 4.5.2 JIS C 5101-3<br>Measuring frequency : 120±12Hz<br>Measuring voltage : 0.5Vrms, +1.5V.DC<br>Measuring circuit : DC Equivalent series circuit                                                                                             |
| Tangent of loss angle<br>(Df, tanδ)                    |            | Shall be satisfied the voltage on "Standard list"                                     |     |     |    |    |    |  | As per 4.8 JIS C 5101-1<br>As per 4.5.3 JIS C 5101-3<br>Measuring frequency : 120±12Hz<br>Measuring voltage : 0.5Vrms, +1.5V.DC<br>Measuring circuit : DC Equivalent series circuit                                                                                             |
| Impedance                                              |            | Shall be satisfied the voltage on "Standard list"                                     |     |     |    |    |    |  | As per 4.10 JIS C 5101-1<br>As per 4.5.4 JIS C 5101-3<br>Measuring frequency : 100±10kHz<br>Measuring voltage : 0.5Vrms or less<br>Measuring circuit : DC Equivalent series circuit                                                                                             |
| Resistance to soldering heat                           | Appearance | There should be no significant abnormality.<br>The indications should be clear.       |     |     |    |    |    |  | As per 4.14 JIS C 5101-1<br>As per 4.6 JIS C 5101-3<br>Dip in the solder bath<br>Solder temp : 260±5°C<br>Duration : 5±0.5s<br>Repetition : 1                                                                                                                                   |
|                                                        | L.C        | Less than initial limit                                                               |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | ΔC / C     | Within ±10% of initial value                                                          |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | tanδ       | Less than 150% of initial limit                                                       |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
| Fail-Safe open unit actuation                          |            | Within 320°C – 20s                                                                    |     |     |    |    |    |  | Dip in the solder bath<br>Solder temp : 320±5°C                                                                                                                                                                                                                                 |
| Temperature cycle                                      | Appearance | There should be no significant abnormality.                                           |     |     |    |    |    |  | As per 4.16 JIS C 5101-1<br>As per 4.10 JIS C 5101-3<br>Repetition : 5 cycles (1 cycle : steps 1 to 4)<br>without discontinuation.                                                                                                                                              |
|                                                        | L.C        | Less than initial limit                                                               |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | ΔC / C     | 1 to 10μF : within ±10% of initial value<br>15 to 22μF : within ±20% of initial value |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | tanδ       | Less than 150% of initial limit                                                       |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
| Moisture resistance                                    | Appearance | There should be no significant abnormality.<br>The indications should be clear.       |     |     |    |    |    |  | As per 4.22 JIS C 5101-1<br>As per 4.12 JIS C 5101-3<br>After leaving the sample under such atmospheric condition that the temperature and humidity are 60±2°C and 90 to 95%RH, respectively, for 500±12h level it at room temperature for 1 to 2h and then measure the sample. |
|                                                        | L.C        | Less than initial limit                                                               |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | ΔC / C     | Within ±20% of initial value                                                          |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |
|                                                        | tanδ       | Less than 150% of initial limit                                                       |     |     |    |    |    |  |                                                                                                                                                                                                                                                                                 |

## Tantalum capacitors

| Item                                                                                                                           |                | Performance                                       | Test conditions<br>(based on JIS C 5101-1 and JIS C 5101-3)                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Temperature Stability                                                                                                          | Temp.          | -55°C                                             | As per 4.29 JIS C 5101-1<br>As per 4.13 JIS C 5101-3                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                | $\Delta C / C$ | Within 0/-15% of initial value                    |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\tan \delta$  | Shall be satisfied the voltage on "Standard list" |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | L.C            | —                                                 |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | Temp.          | +85°C                                             |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\Delta C / C$ | Within +15/0% of initial value                    |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\tan \delta$  | Shall be satisfied the voltage on "Standard list" |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | L.C            | 5 $\mu$ A or 0.1CV whichever is greater           |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | Temp.          | +125°C                                            |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\Delta C / C$ | Within +20/0% of initial value                    |                                                                                                                                                                                                                                                                                                                                                                                  |
| Surge Voltage                                                                                                                  | Appearance     | There should be no significant abnormality.       | As per 4.26 JIS C 5101-1<br>As per 4.14 JIS C 5101-3<br>Apply the specified surge voltage every 5 $\pm$ 0.5min. for 30 $\pm$ 5 s. each time in the atmospheric condition of 85 $\pm$ 2°C.<br>Repeat this procedure 1,000 times.                                                                                                                                                  |
|                                                                                                                                | L.C            | Shall be satisfied the voltage on "Standard list" |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\Delta C / C$ | Within $\pm$ 10% of initial value                 |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\tan \delta$  | Less than 150% of initial limit                   |                                                                                                                                                                                                                                                                                                                                                                                  |
| Loading at High temperature                                                                                                    | Appearance     | There should be no significant abnormality.       | As per 4.23 JIS C 5101-1<br>As per 4.15 JIS C 5101-3<br>After applying the rated voltage for 1000+36/0h without discontinuation via the serial resistance of 3 $\Omega$ or less at a temperature of 85 $\pm$ 2°C, leave the sample at room temperature/humidity for 1 to 2h and measure the value.                                                                               |
|                                                                                                                                | L.C            | Less than initial limit                           |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\Delta C / C$ | Within $\pm$ 10% of initial value                 |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                | $\tan \delta$  | Less than 150% of initial limit                   |                                                                                                                                                                                                                                                                                                                                                                                  |
| Terminal Strength                                                                                                              | Capacitance    | The measured value should be stable.              | As per 4.35 JIS C 5101-1<br>As per 4.9 JIS C 5101-3<br>A force is applied to the terminal until it bends to 1mm and by a prescribed tool maintain the condition for 5s. (See the figure below.)                                                                                                                                                                                  |
|                                                                                                                                | Appearance     | There should be no significant abnormality.       |                                                                                                                                                                                                                                                                                                                                                                                  |
|  <p>(Unit : mm)</p> <p>Thickness 1.6mm</p> |                |                                                   |                                                                                                                                                                                                                                                                                                                                                                                  |
| Adhesiveness                                                                                                                   |                | The terminal should not come off.                 | <p>As per 4.34 JIS C 5101-1<br/>As per 4.8 JIS C 5101-3<br/>Apply force of 5N in the two directions shown in the figure below for 10<math>\pm</math>1s after mounting the terminal on a circuit board.</p>  <p>product</p> <p>C105</p> <p>YAA</p> <p>Apply force</p> <p>a circuit board</p> |

## Tantalum capacitors

| Item                   |             | Performance                                                                                                                | Test conditions<br>(based on JIS C5101-1 and JIS C5101-3)                                                                                                                                                                                                                   |
|------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dimensions             |             | Be based on "External dimensions"                                                                                          | Measure using a caliper of JIS B 7505 Class 2 or higher grade.                                                                                                                                                                                                              |
| Resistance to solvents |             | The indication should be clear.                                                                                            | As per 4.32 JIS C 5101-1<br>As per 4.18 JIS C 5101-3<br>Dip in the isopropyl alcohol for 30±5s, at room temperature.                                                                                                                                                        |
| Solderability          |             | 3/4 or more surface area of the solder coated terminal dipped in the soldering bath should be covered with the new solder. | As per 4.15.2 JIS C 5101-1<br>As per 4.7 JIS C 5101-3<br>Dip speed = 25±2.5mm/s<br>Pre-treatment (accelerated aging) : Leave the sample on the boiling distilled water for 1h.<br>Solder temp. : 235±5°C<br>Duration : 2±0.5s<br>Solder : H63A<br>Flux : Rosin 25%, IPA 75% |
| Vibration              | Capacitance | Measure value should not fluctuate during the measurement.                                                                 | As per 4.17 JIS C 5101-1<br>Frequency : 10 to 55 to 10Hz/min.<br>Amplitude : 1.5mm<br>Time : 2h each in X and Y directions<br>Mounting : The terminal is soldered on a print circuit board.                                                                                 |
|                        | Appearance  | There should be no significant abnormality.                                                                                |                                                                                                                                                                                                                                                                             |

# TCFG series P Case

## Tantalum capacitors

●Table 1 standard list, TCFG series P Case

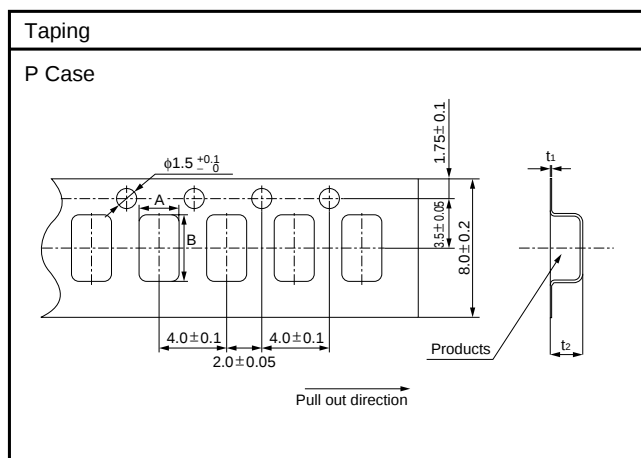
(P : 2012)

| Part No.        | Rated Voltage<br>@85°C<br>(V) | Derated Voltage<br>@125°C<br>(V) | Surge Voltage<br>@85°C<br>(V) | Capacitance<br>120Hz<br>(μF) | Tolerance<br>(%) | Leakage current<br>25°C<br>1WV.60s<br>(mA) | DF120Hz (%) |              |       | Impedance<br>100kHz<br>(Ω) | Case code |
|-----------------|-------------------------------|----------------------------------|-------------------------------|------------------------------|------------------|--------------------------------------------|-------------|--------------|-------|----------------------------|-----------|
|                 |                               |                                  |                               |                              |                  |                                            | -55°C       | 25°C<br>85°C | 125°C |                            |           |
| TCFG P 0G 225□  | 4                             | 2.5                              | 5.2                           | 2.2                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 4.0                        | P         |
| TCFG P 0G 335□  | 4                             | 2.5                              | 5.2                           | 3.3                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 17.5                       | P         |
| TCFG P 0G 475□  | 4                             | 2.5                              | 5.2                           | 4.7                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 14.4                       | P         |
| TCFG P 0G 685□  | 4                             | 2.5                              | 5.2                           | 6.8                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 11.8                       | P         |
| TCFG P 0G 106□  | 4                             | 2.5                              | 5.2                           | 10                           | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 9.3                        | P         |
| TCFG P 0G 156□  | 4                             | 2.5                              | 5.2                           | 15                           | ±20,±10          | 0.6                                        | 30          | 20           | 30    | 8.3                        | P         |
| TCFG P 0G 226□  | 4                             | 2.5                              | 5.2                           | 22                           | ±20,±10          | 0.9                                        | 30          | 20           | 30    | 7.7                        | P         |
| TCFG P 0J 155 □ | 6.3                           | 4                                | 8                             | 1.5                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 17.5                       | P         |
| TCFG P 0J 225□  | 6.3                           | 4                                | 8                             | 2.2                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 4.0                        | P         |
| TCFG P 0J 335□  | 6.3                           | 4                                | 8                             | 3.3                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 14.4                       | P         |
| TCFG P 0J 475□  | 6.3                           | 4                                | 8                             | 4.7                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 11.8                       | P         |
| TCFG P 0J 685□  | 6.3                           | 4                                | 8                             | 6.8                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 9.3                        | P         |
| TCFG P 0J 106□  | 6.3                           | 4                                | 8                             | 10                           | ±20,±10          | 0.6                                        | 30          | 20           | 30    | 8.3                        | P         |
| TCFG P 0J 156□  | 6.3                           | 4                                | 8                             | 15                           | ±20,±10          | 0.9                                        | 30          | 20           | 30    | 7.7                        | P         |
| TCFG P 1A 105□  | 10                            | 6.3                              | 13                            | 1.0                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 17.5                       | P         |
| TCFG P 1A 155□  | 10                            | 6.3                              | 13                            | 1.5                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 16.1                       | P         |
| TCFG P 1A 225□  | 10                            | 6.3                              | 13                            | 2.2                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 4.0                        | P         |
| TCFG P 1A 335□  | 10                            | 6.3                              | 13                            | 3.3                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 11.8                       | P         |
| TCFG P 1A 475□  | 10                            | 6.3                              | 13                            | 4.7                          | ±20,±10          | 0.5                                        | 30          | 20           | 30    | 6.0                        | P         |
| TCFG P 1C 105□  | 16                            | 10                               | 20                            | 1.0                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 16.5                       | P         |
| TCFG P 1D 105□  | 20                            | 13                               | 26                            | 1.0                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 16.1                       | P         |
| TCFG P 1E 105□  | 25                            | 16                               | 33                            | 1.0                          | ±20,±10          | 0.5                                        | 15          | 10           | 15    | 16.1                       | P         |

□=Tolerance (M : ±20%, K : ±10%)

### ●Packaging specifications

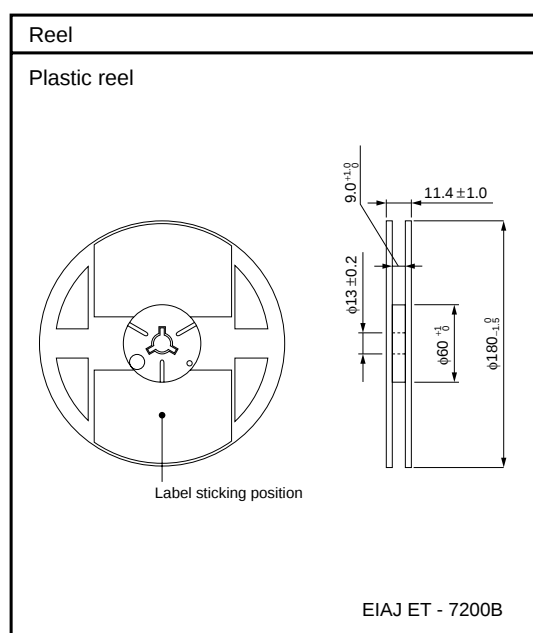
| Case code | A±0.1 | B±0.1 | t <sub>1</sub> ±0.05 | t <sub>2</sub> ±0.1 |
|-----------|-------|-------|----------------------|---------------------|
| P (2012)  | 1.55  | 2.3   | 0.25                 | 1.5                 |



## Tantalum capacitors

## ●Packaging style

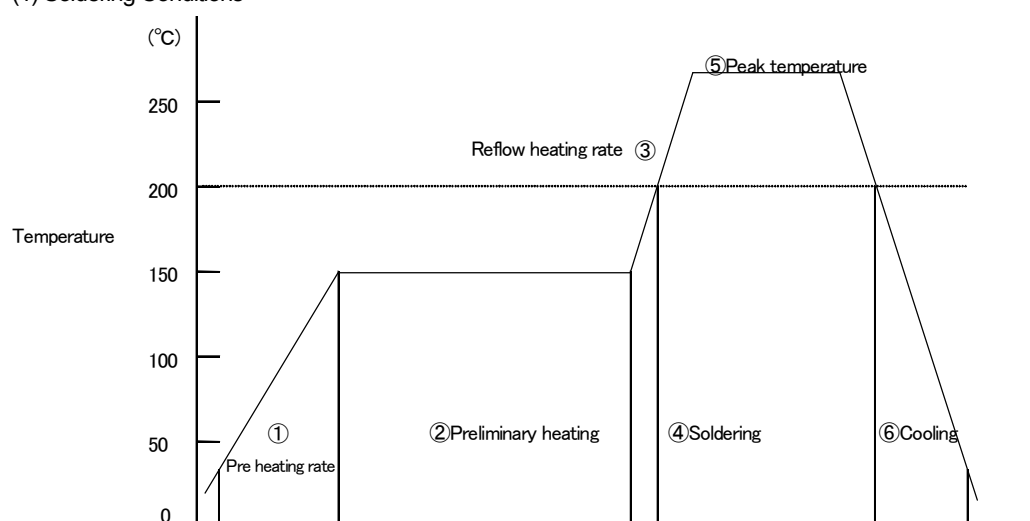
| Case size | Packaging | Packaging style |             | Symbol | Basic ordering unit |
|-----------|-----------|-----------------|-------------|--------|---------------------|
| P Case    | Taping    | Plastic taping  | φ180mm reel | R      | 2,000               |



## Tantalum capacitors

## ● Recommended condition of reflow soldering

## (1) Soldering Conditions



## Recommended condition of reflow soldering

- |                       |                               |
|-----------------------|-------------------------------|
| ① Pre heating rate    | : 1 to 5°C / s                |
| ② Preliminary heating | : 120 to 160°C, 50 to 120s    |
| ③ Reflow heating rate | : 1 to 5°C / s                |
| ④ Soldering           | : 200°C, 30 to 60s            |
| ⑤ Peak temperature    | : 230 to 260°C    10s    Max. |
| ⑥ Cooling             | : 60s    Min.                 |
| ⑦ Time                | : 2times Max.                 |

## Recommended condition of hand soldering

- |                          |              |
|--------------------------|--------------|
| ① Temperature (30W Max.) | : 300°C Max. |
| ② Time                   | : 5s Max.    |

## Flow soldering (Dip • Wave soldering)

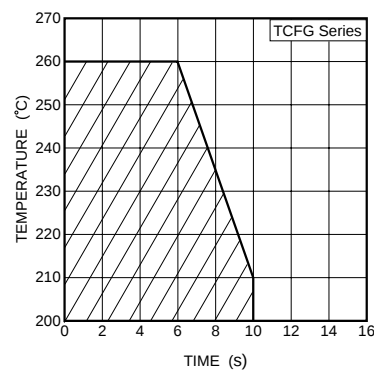


Fig.1

## Tantalum capacitors

### (2) Leakage current-to-voltage ratio

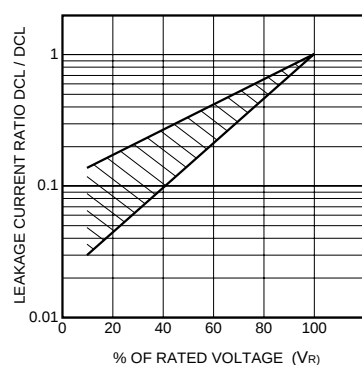


Fig.2

### (3) Derating voltage as function of temperature

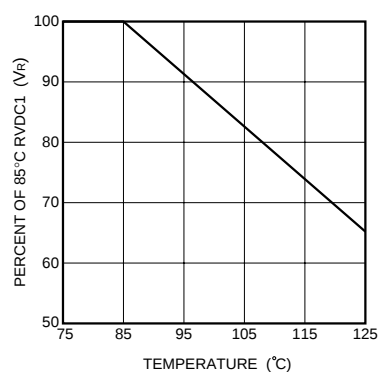


Fig.3

| 85°C                    |                         | 125°C                      |                         |
|-------------------------|-------------------------|----------------------------|-------------------------|
| Rated Voltage<br>(V.DC) | Surge Voltage<br>(V.DC) | Category Voltage<br>(V.DC) | Surge Voltage<br>(V.DC) |
| 4                       | 5.0                     | 2.5                        | 3.4                     |
| 6.3                     | 8                       | 4                          | 5                       |
| 10                      | 13                      | 6.3                        | 9                       |
| 16                      | 20                      | 10                         | 12                      |
| 20                      | 26                      | 13                         | 16                      |

### (4) Reliability

The malfunction rate of tantalum solid state electrolytic capacitors varies considerably depending on the conditions of usage (ambient temperature, applied voltage, circuit resistance).

#### Formula for calculating malfunction rate

$$\lambda_p = \lambda_b \times (\pi_E \times \pi_{SR} \times \pi_Q \times \pi_{CV})$$

$\lambda_p$  : Malfunction rate stemming from operation

$\lambda_b$  : Basic malfunction rate

$\pi_E$  : Environmental factors

$\pi_{SR}$  : Series resistance

$\pi_Q$  : Level of malfunction rate

$\pi_{CV}$  : Capacitance

For details on how to calculate the malfunction rate stemming from operation, see the tantalum solid state electrolytic capacitors column in MIL-HDBK-217.

## Tantalum capacitors

Malfunction rate as function of operating temperature and rated voltage

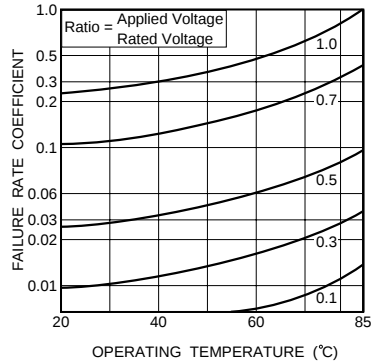


Fig. 4

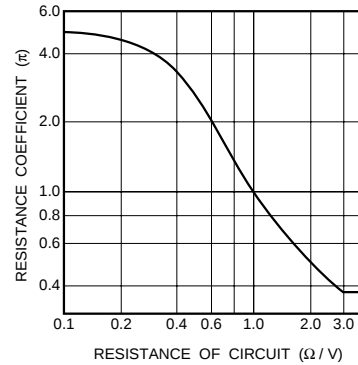
Malfunction rate as function of circuit resistance ( $\Omega/V$ )

Fig. 5

(5) External temperature vs. fuse blowout

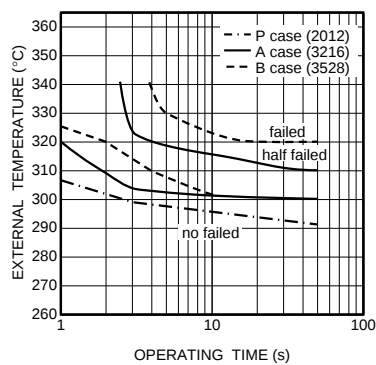


Fig. 6

(6) Power vs. fuse blowout characteristics / Product surface temperature

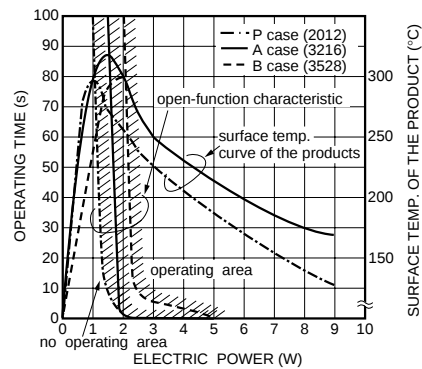


Fig. 7

Note: Solder the chip at 300°C or less. If it is soldered using a temperature higher than 300°C, open function built-in may operate.

(7) Maximum power dissipation

Warming of the capacitor due to ripple voltage balances with warming caused by Joule heating and by radiated heat. Maximum allowable warming of the capacitor is to 5°C above ambient temperature. When warming exceeds 5°C, it can damage the dielectric and cause a short circuit.

$$\text{Power dissipation (P)} = I^2 \cdot R$$

Ripple current

P : As shown in table at right

R : Equivalent series resistance

## Notes:

1. Please be aware that when case size is changed, maximum allowable power dissipation is reduced.
2. Maximum power dissipation varies depending on the package. Be sure to use a case which will keep warming within the limits shown in the table below.

## Tantalum capacitors

Allowable power dissipation (W) and maximum temperature rising

| Case \ Ambient temp | +25°C | +55°C | +85°C | +125°C |
|---------------------|-------|-------|-------|--------|
| P case (2012)       | 0.025 | 0.022 | 0.020 | 0.010  |
| Max. Temp Rise (°C) | 5     | 5     | 5     | 2      |

(8) Impedance frequency characteristics

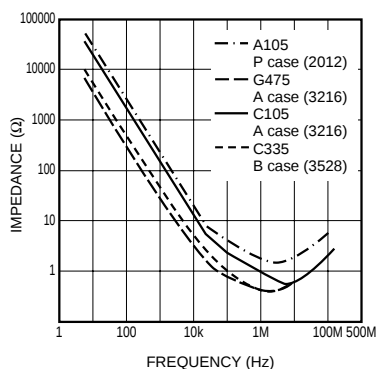


Fig.8

(9) ESR frequency characteristics

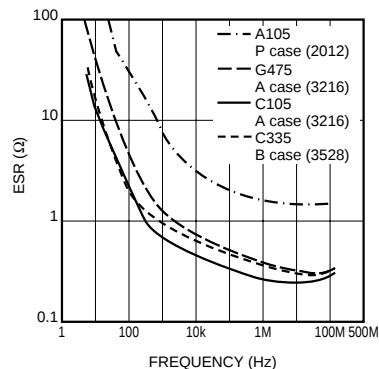


Fig.9

(10) Temperature characteristics

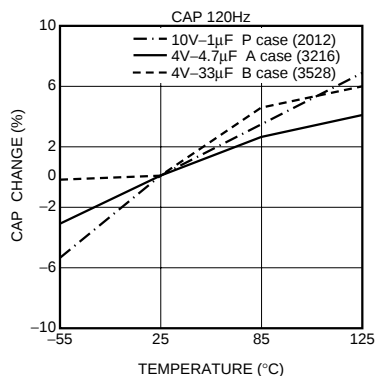


Fig.10

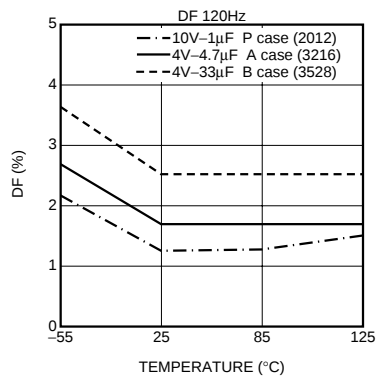


Fig.11

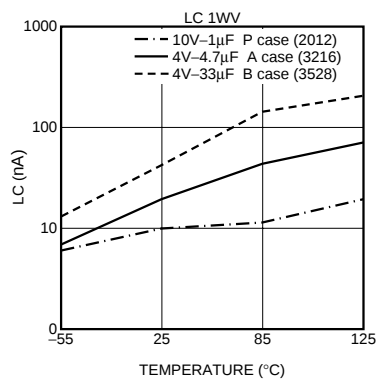


Fig.12

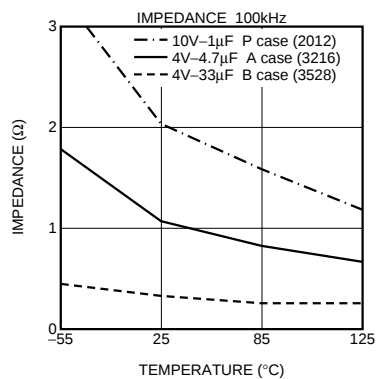


Fig.13

## Tantalum capacitors

## Inrush current

Beware of inrush current.

Inrush currents are inversely proportional ESR. Large inrush currents can cause components failure.

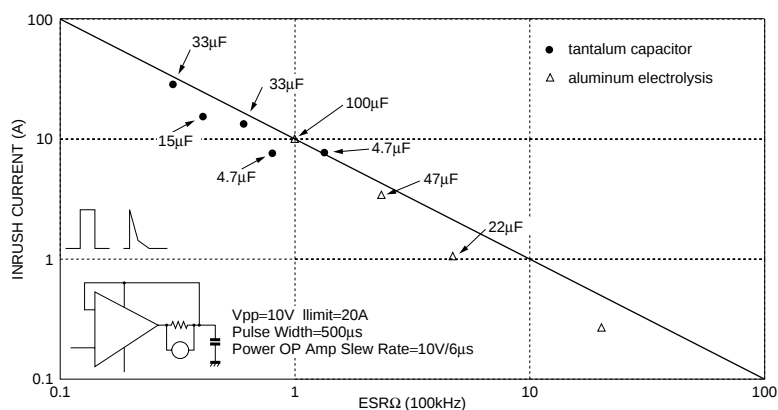


Fig. 14 Maximum inrush current and ESR

Inrush current can be limited by means of a protective resistor.

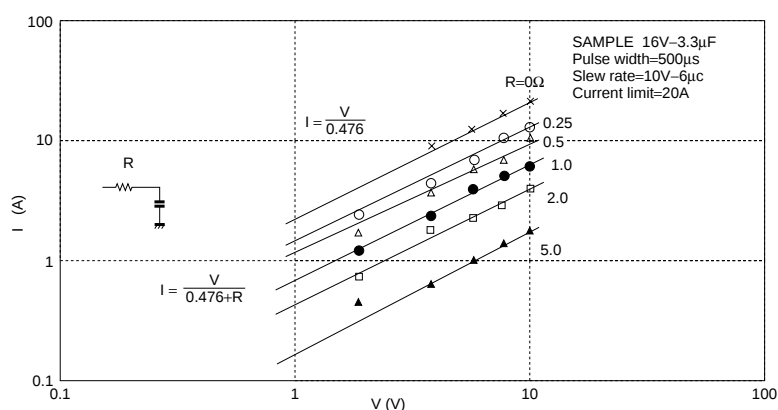


Fig. 15 Imax change due to protective resistor R

## (11) Ultrasonic cleaning

Carry out cleaning as mild conditions as possible. The internal element of a tantalum capacitor are larger than those of a transistor or diode, so it is not as resistant as ultrasonic waves.

Example : water

Propagation speed 1500m / s

Solvent density 1g / cm<sup>3</sup>

Frequency and wavelength

| Frequency | Wavelength |
|-----------|------------|
| 20kHz     | 7.5cm      |
| 28kHz     | 5.3cm      |
| 50kHz     | 3.0cm      |

## Tantalum capacitors

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### ● Precautions

- 1) Do not allow solvent to come to a boil (kinetic energy increases).
  - . Ultrasonic output      0.5W / cm<sup>2</sup> or less
  - . Use a solvent with a high boiling point.
  - . Lower solvent temperature.
- 2) Ultrasonic cleaning frequency  
28 kHz or less
- 3) Keep cleaning time as short as possible.
- 4) Move item being cleaned.  
Standing waves caused by the ultrasonic waves can cause stress to build up in part of the item being cleaned.

### Reference

$$\text{Kinetic energy} = 2 \times \pi \times \text{frequency} \times \sqrt{\frac{2 \times \text{Ultrasonic output}}{\text{propagation} \times \text{speed} \times \text{solvent density}}}$$

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