

## Calculating Failure In Time (FIT) for Ceramic and Tantalum Capacitors

### Introduction

Understanding the performance of a component over time can help to estimate your device’s operational lifetime. Changes in applied voltage and temperature will have an effect on the lifetime of individual components. As a baseline, KEMET provides data that can be used with the MIL-HDBK-217 formula to calculate Failures In Time (FIT) for ceramic and tantalum capacitors.

Measuring the number of failures over time provides a failure rate ( $\lambda$ ). The failure rate that occurs during one billion device hours is called the Failure In Time (FIT). In other words,

$$1 \text{ FIT} = 1 \text{ Failure in } 10^9 \text{ Device Hours}$$

Equation 1: FIT

The Mean Time Between Failure (MTBF), or for components, the Mean Time To Failure (MTTF) is the distribution for a population of components. MTTF can be determined by taking the reciprocal of FIT ( $\lambda$ ).

$$MTTF = \frac{1}{\lambda}$$

Equation 2: MFFT

### KEMET’s FIT Calculator

For calculating FIT values, the free KEMET FIT calculator uses the formulas and constants defined in the military handbook MIL-HDBK-217. A number of pre-defined failure rates are used to calculate the actual in-circuit failure for a part. These failure rates are based on environmental and circuit conditions, also defined in the handbook. Additionally, there is an option to enter a user-defined failure rate from KEMET’s own accelerated life testing (ALT) results, which is typically used to calculate the FIT for commercial grade capacitors.

KEMET’s FIT calculator can be downloaded at [www.kemet.com/fit](http://www.kemet.com/fit).

### Using the KEMET FIT Calculator

Prior to using the FIT calculator, locate key data related to the part. In addition to rated voltage, temperature and capacitance, the user will need the application’s applied voltage and operating temperature. For commercial grade components, it is suggested to use KEMET’s ALT data. Please contact your local KEMET FAE for the latest production data.

### Application Example

In this example, we will calculate a FIT for a commercial grade ceramic capacitor. The part number for the example is C0805C104K1RAC. A summary of specifications are shown in Table 1.

C0805C104K1RAC	
<b>Style</b>	Chip (Surface Mount)
<b>Rated Temperature</b>	+ 125 °C
<b>Capacitance</b>	100nF (0.1µF)
<b>Rated Voltage</b>	100 VDC

Table 1: Summary specification for C0805C104K1RAC

## Step 1: Launch KEMET FIT calculator

After launching the KEMET FIT calculator, Figure 1 is the first window displayed.

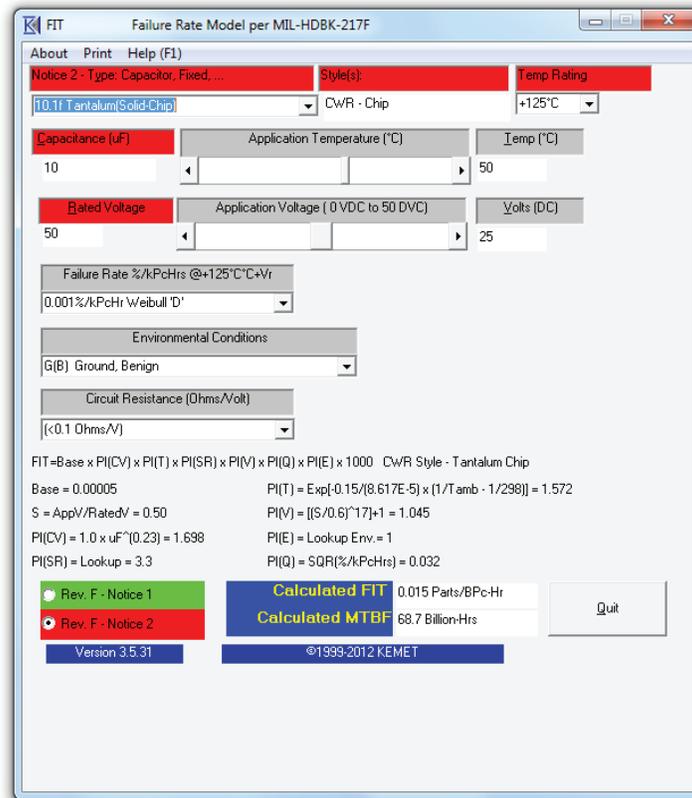


Figure 1: Initial FIT Window

Take note of the dropdown box titled “Failure Rate %/kPcHrs @+125C+Vr.” This is where you can select from the pre-defined failure rates or enter data from ALT. The pre-defined failure rates are suitable for military-grade components. For commercial parts, it is common to enter a user-defined failure rate based on KEMET’s ALT data.

## Step 2: Select Failure Rate Style

For commercial parts, contact KEMET to receive the pieces (Pcs), hours (Hrs) and number of failed parts (Fail). This data is updated on a regular basis.

See the MIL-HDBK-217’s formulas and constants for definitions of the military failure rates shown in the dropdown.

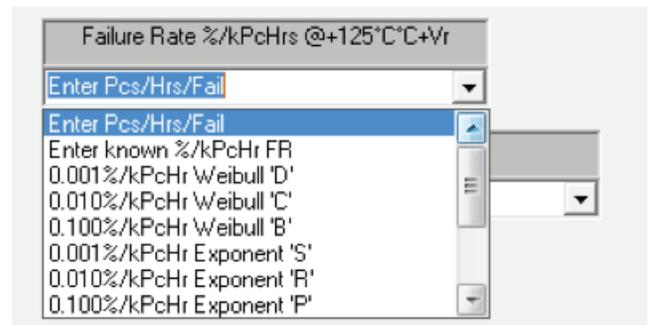
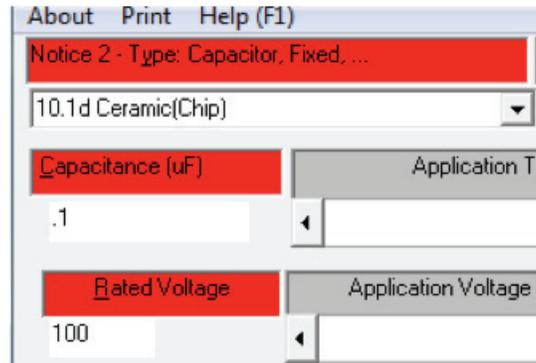


Figure 2: Failure Rate Selection

## Step 3: Enter Capacitor Specifications



Field	Value
Type	10.1d Ceramic(Chip)
Capacitance (uF)	.1
Rated Voltage	100
Application Temperature	
Application Voltage	

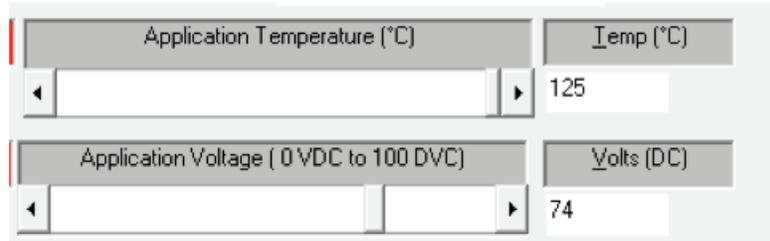
Figure 3: Capacitor Specifics

Using the data gathered in Step 1 (and Table 1 of this example), enter:

- Capacitor Type
- Rated Voltage
- Rated Temperature

(Note that Figure 3 does not show the temperature box.)

## Step 4: Enter the Application's Operating Parameters



Field	Value
Application Temperature (°C)	125
Application Voltage (0 VDC to 100 DVC)	74

Figure 4: Operating Details

The applied voltage and max operational temperature are entered in the Application section of the calculator.

Note: If these values are not known, designers may use 50% of rated voltage and maximum rated temperature of the part. These assumptions should be noted when reporting FIT numbers.

## Step 5: Results

<b>Calculated FIT</b>	19.14 Parts/BPc-Hr
<b>Calculated MTBF</b>	52.2 Million-Hrs

Figure 5: Results

The results are indicated by the blue fields. Both the FIT and MTBF (or MTTF) are shown.

## Additional Details

FIT=Base x PI(CV) x PI(T) x PI(SR) x PI(V) x PI(Q) x PI(E) x 1000	
Base = 0.00005	PI(T) = $\text{Exp}[-0.15/(8.617\text{E-}5) \times (1/T_{\text{amb}} - 1/298)] = 4.339$
<b>S = AppV/RatedV = 1.00</b>	PI(V) = $[(S/0.8)^{17}+1] = 45.409$
PI(CV) = $1.0 \times uF^{(0.23)} = 0.589$	PI(E) = Lookup Env. = 1
PI(SR) = Lookup = 3.3	PI(Q) = $\text{SQRT}(\%/kPcHrs) = 1.000$

Figure 6: Additional Details

The middle section of the calculator displays how the specific results were calculated and what the FIT equation looks like as defined by the MIL-HDBK-217F's formulas. This information is useful to verify the FIT and MTBF calculations.

## Downloading the KEMET FIT Calculator

The KEMET FIT calculator must be downloaded from the KEMET website at: [www.kemet.com/fit](http://www.kemet.com/fit).

For more information on this product go to  
[www.kemet.com/an1002](http://www.kemet.com/an1002) or scan the QR code:

