# SimSurfing
# Multilayer Ceramic Capacitors
# Characteristics Viewer
# Measurement Conditions


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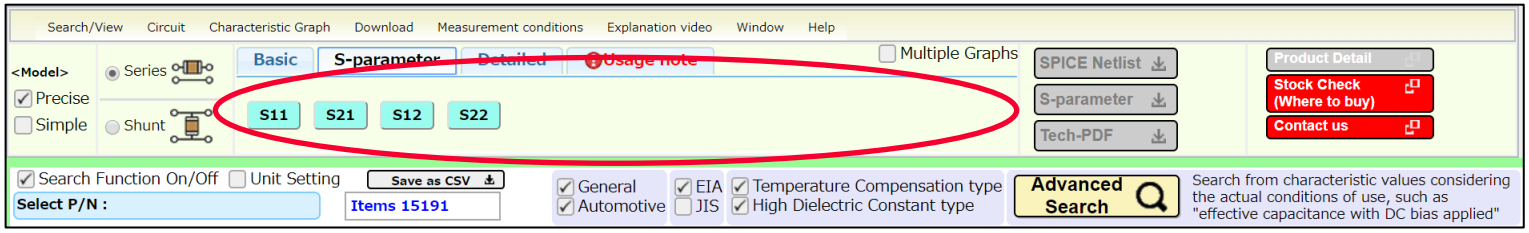
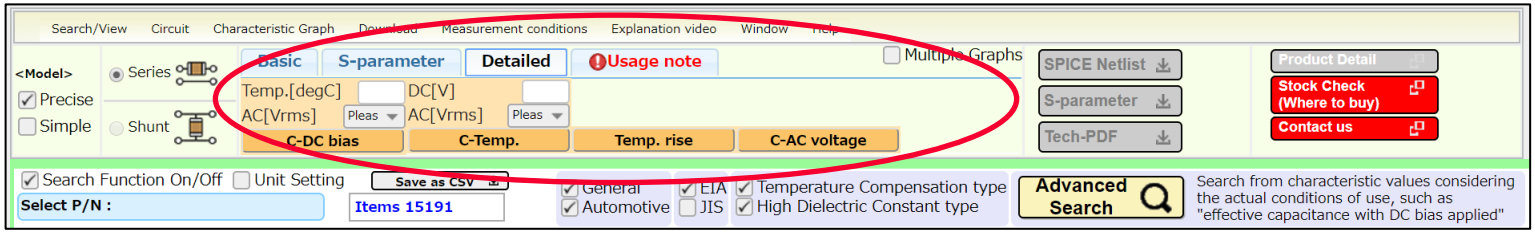
# 1. Outline of this document

Simsurfing provides DC bias characteristics, Temperature characteristics, Temperature rise (Ripple current), AC voltage characteristics and S-parameter in addition to basic characteristics.
This document explains how this data was prepared.



# 2. S-parameter (1/3)

S-parameter library provides the S-parameter data which could be used in circuit designs.
Below are the details of the procedure for measuring S-parameter data, the applied land pattern, the measurement equipment, and the measurement conditions for capacitors.

1. Measurement Procedure
   The measurement procedure is indicated below. The S-parameter data is measured with two ports using a network analyzer and measurement jig, as shown mainly in Fig. 1.

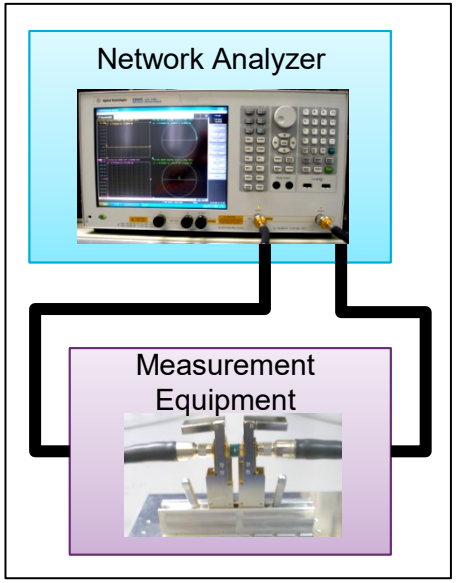


Fig.1 Measurement of S-parameter data

   (1) Correction
   Two kinds of correction, SOLT (partly SOL) and TRL, are used.
   SOLT applies Murata's original land pattern (Short, Open, Load, and Thru).
   Meanwhile, TRL uses Murata's original land pattern (Thru, Reflect, Line, Match).

   (2) Measurement
   After soldering the capacitor to the land pattern, we fix it to a measurement jig connected to a network analyzer, impedance analyzer, and measure it.

   (3) Extraction of S-parameter data for the capacitor alone
   In the S-parameter data, although the characteristics of the land pattern and measurement equipment are eliminated by correction and electrical delay, the characteristics of the via holes and the land pattern are still included in the measurement . Therefore, the data of the capacitor itself is extracted by eliminating the characteristics of the via holes and the land pattern.

# 2. S-parameter (2/3)

2. Land pattern

| Item | max8.5GHz | max20GHz | max30GHz |
|---|---|---|---|
| Substrate material | Glass epoxy resin | Glass fluorine resin | Glass fluorine resin |
| Thickness of layer | 100um | 160um | 80um |
| Substrate structure | Microstrip | Coplanar | Coplanar |
| Intrinsic impedance | 17Ω | 50Ω | 40Ω |
| Pattern material | Copper foil ＋Gold coating | Copper foil ＋Gold coating | Copper foil ＋Gold coating |

| LW Dimension | | Land Pattern[mm] | | |
|---|---|---|---|---|
| JIS[mm] | EIA[inch] | a | b | C |
| 0201M | 008004 | 0.11 | 0.12 | 0.145 |
| 0402M | 01005 | 0.2 | 0.18 | 0.23 |
| 0603M | 0201 | 0.3 | 0.35 | 0.40 |
| 1005M | 0402 | 0.5 | 0.45 | 0.60 |
| 1608M | 0603 | 0.8 | 0.7 | 0.8 |
| 2012M | 0805 | 1.2 | 0.7 | 1.1 |
| 2828M | 1111 | 2.1 | 0.9 | 2.6 |
| 3216M | 1206 | 2.4 | 0.9 | 1.4 |
| 3225M | 1210 | 2.4 | 0.9 | 2.3 |
| 4532M | 1812 | 3.5 | 1.4 | 3.0 |
| 4520M | 1808 | 3.5 | 1.4 | 1.8 |
| 5750M | 2220 | 4.6 | 1.6 | 4.8 |
| 0510M | 0204 | 0.2 | 0.3 | 1.0 |
| 0816M | 0306 | 0.3 | 0.4 | 1.6 |
| 1220M | 0508 | 0.6 | 0.5 | 1.8 |
| 1632M | 0612 | 0.8 | 0.7 | 2.8 |
| 2040M | 0816 | 0.9 | 0.8 | 4.0 |

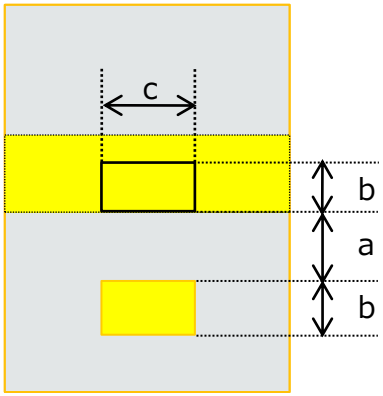



Fig.2　Structure of Land Pattern

3. Measurement Equipment

Listed below is the equipment used in the measurements.

[Temperature compensating type capacitor] (For a capacitor of 1000 pF or more, the same conditions as those used for a high dielectric constant type capacitor are used.)

(1) Impedance analyzer : E4991A/B (Keysight Technologies)
(2) Network Analyzer : E5071C/N5225A (Keysight Technologies)
(3) Measurement jig : PC-SMA/PC-V (YOKOWO)

[High dielectric constant type capacitor]

(1) Impedance analyzer : E4990A/4294A (Keysight Technologies)
(2) Network Analyzer : E5061B/E5071C (Keysight Technologies)
(3) Measurement jig : PC-SMA (YOKOWO)

# 2. S-parameter (3/3)

4. Measurement Condition

In the measurements, the frequency is classified into a higher range and a lower range. The proper conditions are applied to each frequency. Table 1 shows the measurement conditions for a temperature compensating type capacitor, and Table 2 shows the measurement conditions for a high dielectric constant type capacitor.

| Types of freq. | Lower Freq. | Higher Freq. 1 | Higher Freq. 2 | Higher Freq. 2 |
|---|---|---|---|---|
| Network Analyzer/ Impedance Analyzer | E4991A/B Keysight Technologies | E5071C Keysight Technologies | N5225A Keysight Technologies | N5225A Keysight Technologies |
| Range of freq. | 100MHz to 3GHz | 100MHz to 8.5GHz | 500MHz to 20GHz | 100MHz to 30GHz |
| Correction Kit | SOL (+ low-loss capacitor) | TRL | | SOLT + de-embedding |
| Connection Mode | 1port | 2 port shunt mode | | |

Table 1 Measurement conditions for a temperature compensating type capacitor

| Types of freq. | Lower Freq. 1 | Lower Freq. 2 | Higher Freq. |
|---|---|---|---|
| Network Analyzer/ Impedance Analyzer | E4990A/4294A Keysight Technologies | E5061B Keysight Technologies | E5071C Keysight Technologies |
| Range of freq. | 100Hz to 100kHz | 100Hz to 100kHz | 100kHz to 6GHz |
| Correction Kit | SOL | SOLT | TRL |
| Connection Mode | | 2 port shunt mode | |

Table 2 Measurement conditions for a high dielectric constant type capacitor

# 3. DC Bias Characteristics (1/2)

The capacitance of multilayer ceramic chip capacitors changes when DC bias voltage is applied. There are two types of multilayer ceramic capacitors: capacitors for temperature compensation and high dielectric constant capacitors. Capacitors for temperature compensation (C0G type etc.) hardly change when DC bias voltage is applied. On the other hand, the high dielectric constant type (X5R type etc.) changes when DC bias voltage is applied. Fig.3 shows an example of the DC bias characteristics of the C0G type and X5R type.

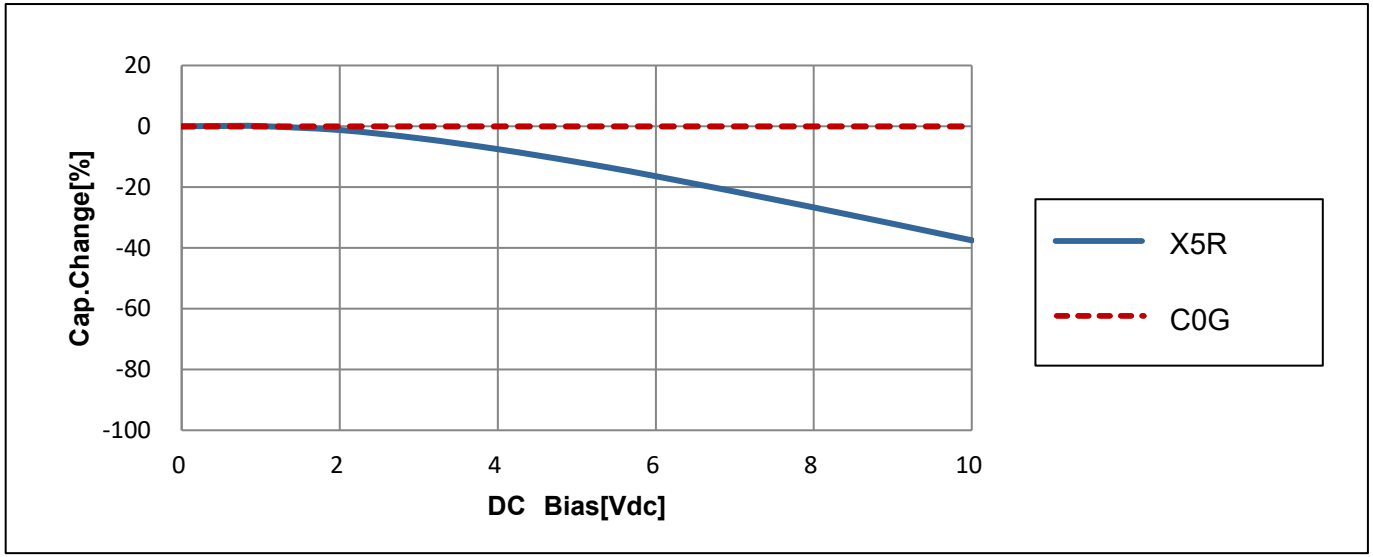



Fig.3 An example of DC bias characteristics

Simsurfing provides the capacitance value and capacitance change rate at any DC bias voltage. Simsurfing will not show DC bias effects on capacitance for C0G/NP0 type capacitors because they do not experience a remarkable change in capacitance.

# 3. DC Bias Characteristics (2/2)

1. Measurement Equipment
   Typical measurement equipment is shown below. (Fig.4 and Fig.5)

Fig.4 Measurement equipment: LCRmeter E4980A
（Keysight Technologies）


Fig.5 Measurement jig: Test fixture16034E/G
（Keysight Technologies）

2. Measure Settings (C: nominal capacitance)
   (1) Measure frequency : C≦10uF 1kHz, C＞10uF 120Hz
   (2) Measure voltage*: C≦10uF（6.3V以下） & C＞10uF 0.5Vrms
   C≦10uF（10V以上） 1Vrms
   (3) DC bias voltage : From 0Vdc to Rated voltage
   (4) DC bias apply duration : 60 sec
   (5) Measure temperature : 25℃±3℃

* For some items, measure voltage is different from others.

# 4. Temperature Characteristics (1/2)

The capacitance of multilayer ceramic chip capacitors changes with temperature. Therefore EIA standards classify temperature characteristics. There are two types of chip multilayer ceramic capacitors: capacitors for temperature compensation and high dielectric constant capacitors. Capacitors for temperature compensation (C0G, NP0 type etc.) show little change in capacitance due to temperature. On the other hand, the high dielectric constant type (X5R, X7R etc.) demonstrates a typical change in temperature. Fig.6 shows an example of the temperature characteristics of the C0G type and X5R type. Table.3 lists the operating temperature range and capacitance tolerance of the C0G type and X5R type.

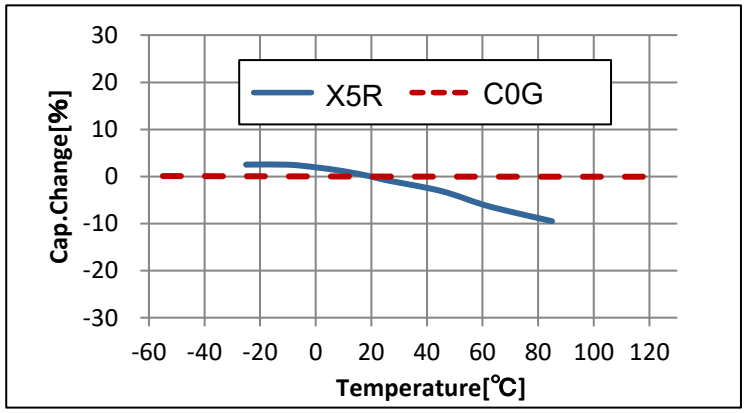



Fig.6 Temperature characteristics

| Code | Operating Temperature Range | Capacitance Change or Temperature Coefficient |
|---|---|---|
| C0G | -55 to 125℃ | 0±30ppm/deg ℃ |
| X5R | -25 to 85℃ | ±15% |

Table.3 Temperature characteristics (EIA)

Simsurfing provides capacitance value and capacitance change rate at any temperature. Additionally, Simsurfing provides temperature characteristics at 50% rated voltage (VDC). Simsurfing will not show temperature effects on capacitance for C0G/NP0 type capacitors because they do not experience a remarkable change in capacitance.

# 4. Temperature Characteristics (2/2)

1. Measurement equipment
   Typical measurement equipment is listed below.
   (1) LCR Meter : E4980A/4284A（Keysight Technologies）
   (2) Test chamber : Thermostatic chamber

2. Measuring conditions (C: Nominal Capacitance)
   (1) Measuring Frequency : C≦10uF 1kHz, C＞10uF 120Hz
   (2) AC voltage* : C≦10uF（6.3V and less） and C＞10uF 0.5Vrms
   C≦10uF（10V and over） 1Vrms
   (3) DC bias : 50% of the related voltage (VDC)
   (4) DC bias applied time : 60 sec

   * For some items, measure voltage is different from others.

# 5. Temperature Rise Characteristics (1/2)

When ripple current is applied to multilayer ceramic chip capacitors, the capacitor generates heat. This internal temperature rise cannot be disregarded. While Murata does not guarantee a ripple current rating, it is recommended that the temperature rise does not exceed 20℃. Fig.7 show a temperature rise characteristics of high dielectric type of capacitors.

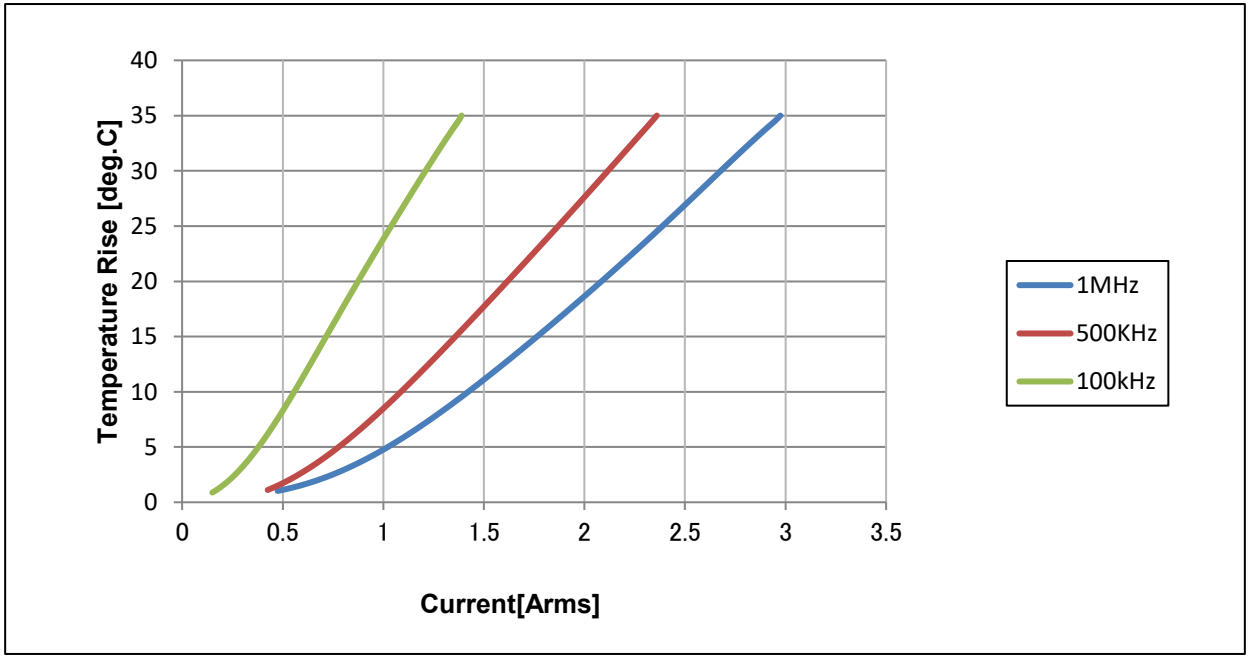



Fig.7 Temperature Rise Characteristics

Simsurfing provides temperature rise characteristics at 50% of the rated voltage (VDC). Simsurfing provides this data for high dielectric constant type capacitors that have a capacitance value of 1uF or greater.

# 5. Temperature Rise Characteristics (2/2)

1. Measurement Equipment

Fig.8(a) shows a circuit diagram of this measuring system. The test device is soldered onto a glass epoxy board and put into an acrylic box. An infrared thermometer is attached on the top surface of the acrylic box to measure chip's surface temperature. Fig8(b) shows a model diagram of the acrylic box.

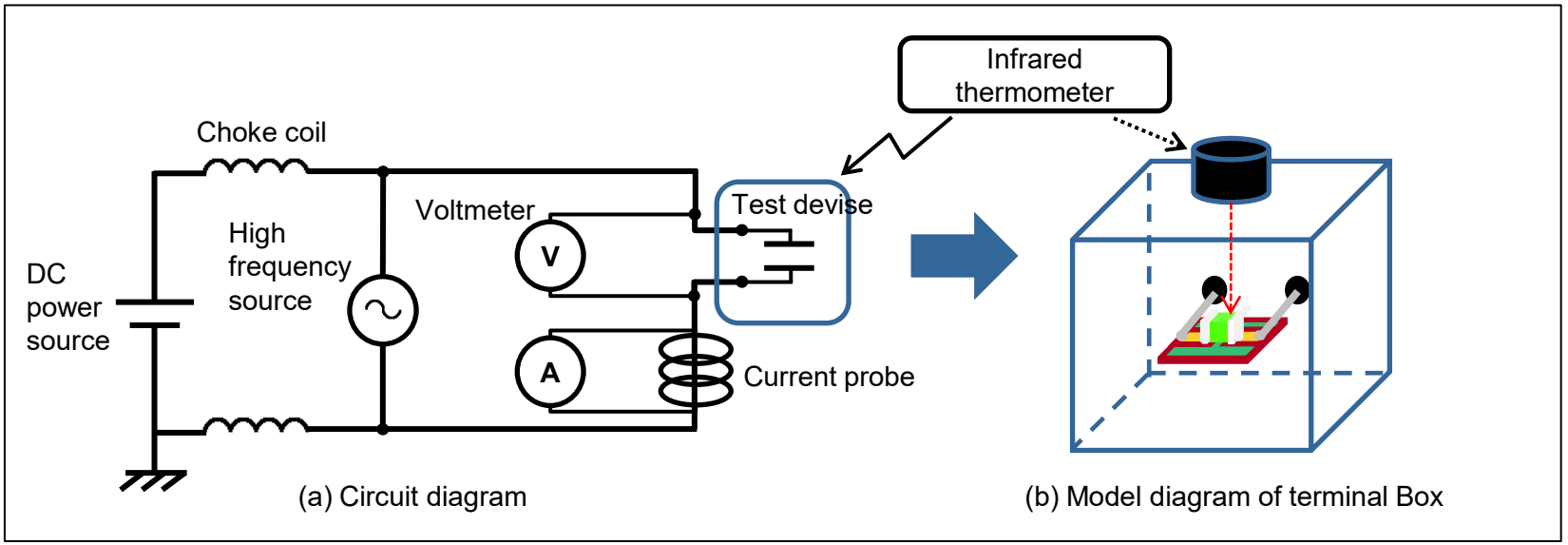



Fig.8 Temperature rise characteristics

2. Measurement Conditions

| | |
|---|---|
| (1) Ripple frequency | : Up to three conditions in the range from 20kHz to 1MHz (Sine wave) |
| (2) Measurement base temperature | : 25℃±3℃ |
| (3) DC bias | : 50% of rated voltage (VDC) |

# 6. AC Voltage Characteristics (1/2)

The capacitance of monolithic ceramic chip capacitors changes when AC voltage is applied. Those capacitors are classified into temperature compensation type and high dielectric constant type. The capacitance of the temperature compensation type (C0G, NP0 type, etc.) rarely changes when AC voltage is applied. However, the capacitance of the high dielectric constant type (X5R) changes when AC voltage is applied. Fig.9 shows the typical AC voltage data of both C0G and X5R types.

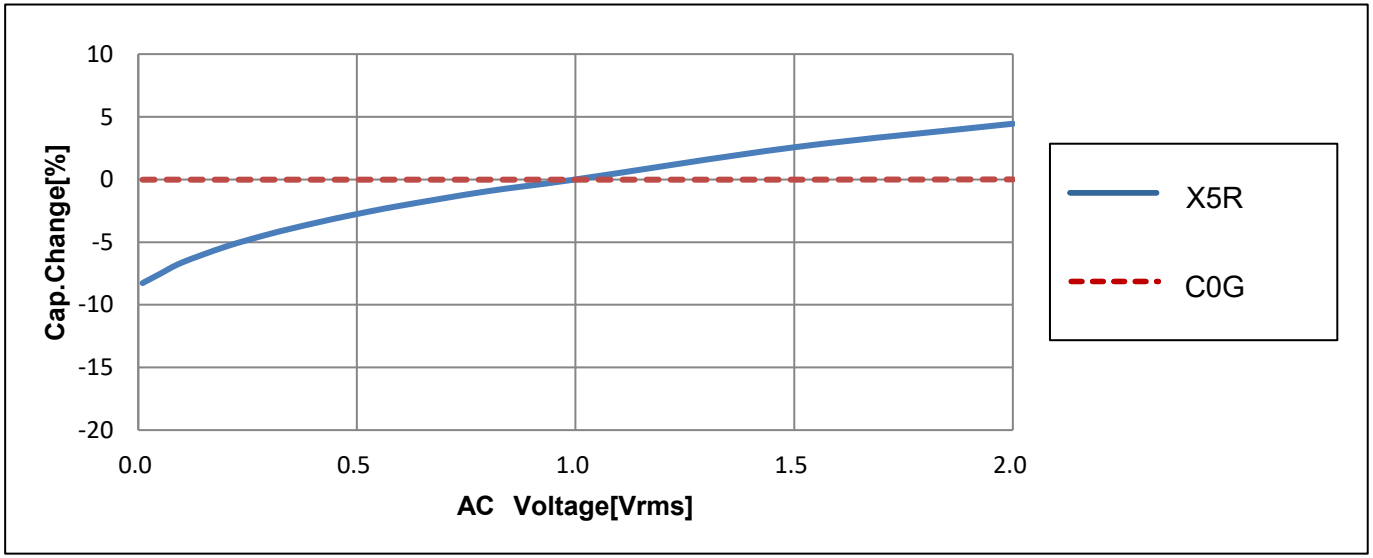



Fig.9 AC Voltage Characteristics Data

Simsurfing provides the capacitance data and the change of capacitance value by an optional AC voltage. However, Simsurfing does not include the data of capacitors that are of the temperature compensating type as there is no influence by AC voltage.

# 6. AC Voltage Characteristics (2/2)

1. Measurement Equipment
   Typical measure equipment is shown below. (Fig.4 and Fig.5)

Fig.4 Measurement Equipment: LCRmeter E4980A
(Keysight Technologies)


Fig.5 Measurement jig: Test fixture16034E/G
(Keysight Technologies)

2. Measurement Conditions (C: nominal capacitance)
   (1) Frequency : C≦10uF 1kHz, C＞10uF 120Hz
   (2) AC bias voltage : 0.01 to 2.0Vrms
   (3) Time : 30 sec
   (4) Temperature : 25℃±3℃