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

1. DC bias characteristics  (C-DC bias)
2. Temperature characteristics  (C-Temp.)
3. Temperature rise (Ripple current)  (Temp.rise)
4. AC voltage characteristics  (C-AC Voltage)
5. S-parameter  (S11,S21,S12,S22)
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.1 shows an example of the DC bias characteristics of the C0G type and X5R type.

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.

**Measurement Equipment**

Typical measurement equipment is shown below.

**Measure Settings** *(C: nominal capacitance)*

1. Measure frequency       : C ≤ 10uF 1kHz,  C > 10uF 120Hz
2. Measure voltage*       : C ≤ 10uF (6.3V or less) & C > 10uF 0.5Vrms
3. DC bias voltage        : C ≤ 10uF (over 10V) 1Vrms
4. DC bias apply duration : From 0Vdc to Rated voltage
5. Measure temperature    : 25°C ± 3°C

* For some items, measure voltage is different from others.
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.1 shows an example of the temperature characteristics of the C0G type and X5R type. Table.1 lists the operating temperature range and capacitance tolerance of the C0G type and X5R type.

![Temperature Characteristics](image)

**Table.1** Temperature characteristics (EIA)

<table>
<thead>
<tr>
<th>Code</th>
<th>Operating Temperature Range</th>
<th>Capacitance Change or Temperature Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0G</td>
<td>-55 to 125°C</td>
<td>±0±30ppm/deg.C</td>
</tr>
<tr>
<td>X5R</td>
<td>-55 to 85°C</td>
<td>±15%</td>
</tr>
</tbody>
</table>

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.

### Measurement equipment

Typical measurement equipment is listed below.

1. LCR Meter : 4284A(Agilent Technologies)
2. Test chamber : Thermostatic chamber

### 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 : 1 min

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

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°C. Fig.1 show a temperature rise characteristics of high dielectric type of capacitors.

![Temperature Rise Characteristics](image)

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.

### Measurement Equipment

Fig.2(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. Fig2(b) shows a model diagram of the acrylic box.

![Measurement Equipment](image)

### Measurement Conditions

1. Ripple frequency : 100kHz, 500kHz, 1MHz (Sine wave)
3. DC bias : 50% of rated voltage (VDC)
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.1 shows the typical AC voltage data of both C0G and X5R types.

![AC Voltage Characteristics](image)

**Measurement Equipment**

Typical measure equipment is shown below.

![Measurement Equipment: LCR meter E4980A](image)

![Measurement jig: Test fixture 16034E/G](image)

**Measurement Conditions** (C: nominal capacitance)

1. Frequency
   - C $\leq$ 10uF  1kHz, C $>$ 10uF  120Hz
2. AC bias voltage
   - 0.01 $\sim$ 2.0Vrms
3. Time
   - 30 sec.
4. Temperature
   - 25°C $\pm$ 3°C
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.

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.

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) to the lower frequency area. Meanwhile, TRL uses Murata’s original land pattern (Thru, Reflect, Line, Match) for the higher frequency range.

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.
Land pattern

<table>
<thead>
<tr>
<th>Item</th>
<th>max8.5GHz</th>
<th>max20GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate material</td>
<td>Glass epoxy resin</td>
<td>Glass fluorine resin</td>
</tr>
<tr>
<td>Thickness of layer</td>
<td>100um</td>
<td>160um</td>
</tr>
<tr>
<td>Substrate structure</td>
<td>Microstrip</td>
<td>Coplanar</td>
</tr>
<tr>
<td>Intrinsic impedance</td>
<td>17Ω</td>
<td>50Ω</td>
</tr>
<tr>
<td>Pattern material</td>
<td>Copper foil + Gold coating</td>
<td>Copper foil + Gold coating</td>
</tr>
</tbody>
</table>

Fig.2 Structure of Land Pattern

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. Network Analyzer: E5071C/N5225A (Agilent Technologies)
2. Impedance analyzer: E4991A (Agilent Technologies)

[High dielectric constant type capacitor]

1. Network Analyzer: E5061B/E5071C (Agilent Technologies)
2. Measurement jig: PC-SMA (YOKOWO)
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.

Table 1 Measurement conditions for a temperature compensating type capacitor

<table>
<thead>
<tr>
<th>Types of freq.</th>
<th>Lower Freq.</th>
<th>Higher Freq. 1</th>
<th>Higher Freq. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Analyzer/Impedance Analyzer</td>
<td>E4991A Agilent Technologies</td>
<td>E5071C Agilent Technologies</td>
<td>N5225A Agilent Technologies</td>
</tr>
<tr>
<td>Range of freq.</td>
<td>100MHz~3GHz</td>
<td>100MHz~8.5GHz</td>
<td>500MHz~20GHz</td>
</tr>
<tr>
<td>Correction Kit</td>
<td>SOL (+ low-loss capacitor)</td>
<td>TRL</td>
<td></td>
</tr>
<tr>
<td>Connection Mode</td>
<td>1 port</td>
<td>2 port shunt mode</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Measurement conditions for a high dielectric constant type capacitor

<table>
<thead>
<tr>
<th>Types of freq.</th>
<th>Lower Freq.</th>
<th>Higher Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Analyzer</td>
<td>E5061B Agilent Technologies</td>
<td>E5071C Agilent Technologies</td>
</tr>
<tr>
<td>Range of freq.</td>
<td>100Hz~100kHz</td>
<td>100kHz~6GHz</td>
</tr>
<tr>
<td>Correction Kit</td>
<td>SOLT</td>
<td>TRL</td>
</tr>
<tr>
<td>Connection Mode</td>
<td>2 port shunt mode</td>
<td></td>
</tr>
</tbody>
</table>