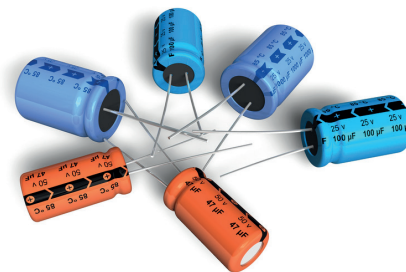


# ELECTROLYTIC CAPACITORS

## How are electrolytic capacitors measured?

The measurement conditions used to define an electrolytic capacitor's capacitance are set forth in IEC standards, and the nominal values cited by capacitor manufacturers are measured values obtained in accordance with those standards. However, because the capacitance values of electrolytic capacitors vary greatly with the measurement frequency, capacitance values should be checked at the frequency at which the circuit in question will actually be used.

Measure the equivalent series resistance (ESR), which includes factors such as the resistance of the electrolytic capacitor's internal electrodes and the electrolyte resistance, and the tangent D ( $\tan\delta$ ) of the loss angle under the same conditions as the capacitance.



## Setting example of measurement conditions

Parameters	Cs - D - Rs
Frequency	120 Hz, frequency at which circuit will actually be used
DC bias	ON 1.0 V
Signal level	0.5 Vrms
Measurement range	AUTO
Speed	SLOW2
LowZ mode	ON

\*Otherwise, default settings are used.

\*The above settings apply to an example measurement. Since optimal conditions vary with the measurement target, specific settings should be determined by the instrument operator.

Fixed capacitors for use in electronic equipment Part 4: Sectional specification  
Aluminium electrolytic capacitors with solid (MnO<sub>2</sub>) and non-solid electrolyte (JIS C5101-4)

Parameters	Rated capacitance	Rated voltage	Measurement Frequency	Measurement Voltage *1	DC bias *2
C,D ( $\tan\delta$ ) Rs (ESR)	ALL	ALL	100 Hz or 120 Hz	5 Vrms	0.7 to 1.0 V

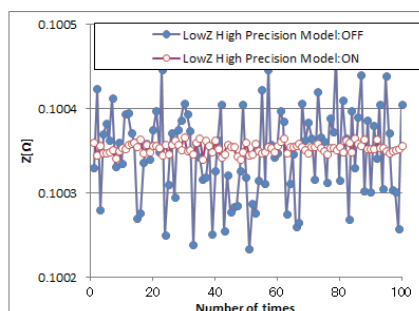
\*1 The measurement voltage (i.e., the voltage applied to the sample) is the voltage obtained by dividing the open-terminal voltage by the output resistance and the sample.

\*1 The measurement voltage (i.e., the voltage applied to the sample) can be calculated based on the open-terminal voltage, the output resistance, and the sample's impedance.

\*2 DC bias need not be applied.

## Low impedance high accuracy mode

In low impedance high accuracy mode, the instrument's output resistance is reduced, and the measurement current is applied repeatedly for increased measurement precision. When measuring a capacitor with a high capacitance of greater than 100 $\mu$ F (and therefore low impedance), low-impedance high-precision mode yields more stable measurement. The graph below compares repeatability when using the IM3570 to make measurements with low-impedance high-precision mode enabled and disabled (100kHz, 1 $\Omega$  range, 1V).



Repeated measurement of a resistance of approximately 100 m $\Omega$  with the IM3570

\*The conditions under which low-impedance high-precision mode can be enabled vary with the instrument model. Please refer to the instruction manual of the instrument you are using.

## Products used

Mass Production Applications

Model	Measurement frequency	Features
IM3523	DC, 40 Hz to 200 kHz	Measurement time : 2ms, high cost performance
IM3533	DC, 1 mHz to 200 kHz	Internal DC bias function, touch panel

Research and Development Applications

Model	Measurement frequency	Features
IM3570 IM9000	DC, 4 Hz to 5 MHz	Frequency sweep with analyzer mode Optional equivalent circuit analysis firmware for the IM3570
IM3590	DC, 1 mHz to 200 kHz	Can measure ESR and ESL separately with its equivalent circuit analysis function

\*For more information, please see the product catalog.

## Equivalent series resistance (ESR) and loss coefficient D (tanδ)

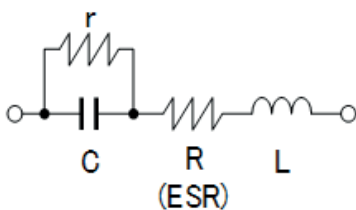
The figure below illustrates a standard equivalent circuit for an electrolytic capacitor.

At low frequencies (50 Hz to 1 kHz), the reactance (XL) resulting from the equivalent series inductance L is extremely small and can be considered to be zero. The resistance and reactance components of each element at this time are characterized by the vector relationship shown in the figure on a complex plane.

An ideal capacitor would have R = 0 and a loss coefficient D = 0, but since actual capacitors have various resistance components, including electrode foil resistance, electrolyte resistance, and contact resistance of leads and other parts, the equivalent series resistance ESR and loss coefficient D (tanδ) serve as useful indicators for use in evaluating electrolytic capacitor quality.

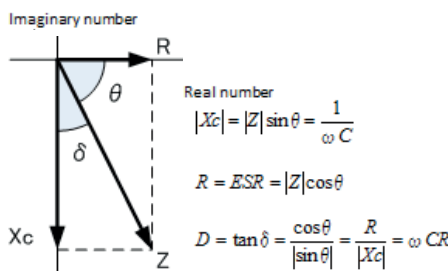
Since the IM3533 and IM3536 can simultaneously measure and display four parameters, they can be used to simultaneously check the reactance X, capacitance C, equivalent series resistance Rs, and loss coefficient D as indicators for use in evaluating electrolytic capacitors, as shown in the example screenshots below.

### Equivalent circuit of Electrolytic capacitors



C: Capacitance  
r: Equivalent series resistance of anodic oxidation coatings  
R: Equivalent series resistance (ESR)  
L: Equivalent series inductance  
\*General Description of Aluminum Electrolytic Capacitors (NECHICON CORPORATION)

### Vector diagram



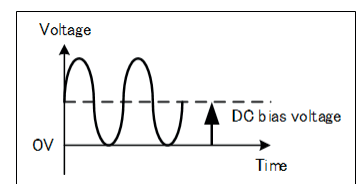
### Display example of IM3536



## DC bias measurement function

Electrolytic capacitors generally are available in polarized and bipolar variants. A DC bias voltage must be applied to polarized capacitors as necessary to prevent application of a reverse voltage.

Since the IM3533 and IM3536 provide a built-in DC bias voltage function, they can apply a DC bias to capacitors, eliminating the need for an external DC power supply.



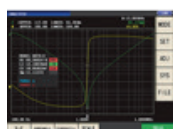
## Determining Cs and Cp

Generally speaking, series equivalent circuit mode is used when measuring low-impedance elements (approximately 100Ω or less) such as high-capacitance capacitors, and parallel equivalent circuit mode is used when measuring high-impedance elements (approximately 10 kΩ or greater) such as low-capacitance capacitors. When the appropriate equivalent circuit mode is unclear, for example when measuring a sample with an impedance from approximately 100Ω to 10 kΩ, check with the component's manufacturer.

## Related Products List



CHEMICAL  
IMPEDANCE ANALYZER  
IM3590



EQUIVALENT CIRCUIT  
ANALYSIS FIRMWARE  
IM9000



IMPEDANCE ANALYZER  
IM3570



LCR METER  
IM3533



LCR METER  
IM3523