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SANYO

Aluminum Solid Capacitors with Conductive Polymer
Aluminum Solid Capacitors with Organic Semiconductive Electrolyte

2007-10

OS-CONTM

TECHNICAL BOOK Ver.15

www.edc.sanyo.com

About this catalog

- The contents of this catalog are current as of September 2007. They may change without prior notice. When ordering products, please be sure to request a delivery specifications form and read it carefully.
- Do not use the **OS-CON** for life-threatening applications (space equipment, aerial equipment, nuclear equipment, life-threatening medical equipment, vehicle control equipment, etc.). However, SVP, SVQP, SVPD, SEP and SEQP are adaptable with our special levels, be sure to consult with us and exchange delivery specification before use.
- The performance, characteristics, and features of the products described in this catalog are based on the products working alone under prescribed conditions. Data listed here is not intended as a guarantee of performance when working as part of any other product or device. In order to detect problems and situations that cannot be predicted beforehand by evaluation of supplied data, please always perform necessary performance evaluations with these devices as part of the product that they will be used in.
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- Please understand that we cannot be held responsible for any damages to the industrial properties of any third party that arise from the use or application of the products listed in this catalog, with the exception of those items directly related to method of construction.

Information and wish

- ① Since the following models of the SC, SA, SL, SH, SVP and SVQP series have been integrated into models with a higher voltage rating, please consider these higher voltage rating models for new adoption or model changes.

Series	Size Code	Applicable model	Alternative model	Series	Size Code	Applicable model	Alternative model
SC	A	16SC1M	25SC1M	SVP	A5	6SVP15M	10SVP15M
		16SC1R5M	25SC1R5M			4SVP22M	6SVP22M
	B	6SC10M	10SC10M		B6	10SVP22M	16SVP22M
	C	16SC10M	25SC10M			6SVP33M	10SVP33M
		6SC22M	10SC22M		C6	6SVP56M	10SVP56M
	D	6SC47M	10SC47M			4SVP82M	6SVP82M
SA	C	10SA33M	16SA33M		E7	10SVP82M	16SVP82M
	E	10SA100M	16SA100M			6SVP120M	10SVP120M
SL	B'	6SL10M	10SL10M			6SVP150M	10SVP150MX
		6SL22M	10SL22M			4SVP150M	10SVP150MX
	C'	6SL33M	10SL33M			4SVP220M	6SVP220MX
		6SL47M	10SL47M		F8	4SVP470M	6SVP470MX
SH	A	16SH1M	25SH1M	SVQP	E7	6SVQP150M	10SVQP150M
		16SH1R5M	25SH1R5M			4SVQP220M	6SVQP220M
	C	16SH10M	25SH10M				

- ② Production of the SG and SV series has been discontinued. Therefore, customers using these series at present are kindly requested to substitute the SP series for the SG series, and the SVP series for the SV series.
- ③ Production of the SM, SN and SPA series is scheduled to be discontinued upon receiving customers' approval. Please use the SVP series for the SM and SN series, and the SP series instead of the SPA series for new board design.




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- The data listed here is only representative of **OS-CON**, and does NOT show any guaranteed value.
- Change in product specifications, dimensions, etc. may occur without prior notice. Be sure that when placing order, please ask for specifications of each series in delivery, and read them well before use.

Classification	Series	Features					Category Temperature Range (°C)	Rated Voltage Range (V.DC)	Capacitance Range (μF)	External Appearance	Marking Color	Page
			Large capacitance	Low ESR	High voltage	Long life						
Conductive polymer electrolyte	SMD type 	NEW SVPE	Super low ESR, large capacitance	●	●		−55°C~+105°C	2.5	390	—	Purple	18 19
		SVPS	Long life			●	−55°C~+105°C	4~25	10~680	—	Purple	20 21
		SVPD	Guaranteed at 125°C, rated 35V max.		●		−55°C~+125°C	10~35	8.2~82	—	Purple	22 23
		UP GRADE SVPC	Large capacitance, super low ESR	●	●		−55°C~+105°C	2.5~16	39~2700	—	Purple	24 25
		SVPB	Low profile				−55°C~+105°C	2.5~20	15~120	—	Purple	26 27
		SVPA	Low ESR, large ripple current		●		−55°C~+105°C	2.5~20	10~820	—	Purple	28 29
		SVQP	Guaranteed at 125°C				−55°C~+125°C	4~20	22~220	—	Purple	30 31
		SVP	Standard				−55°C~+105°C	2.5~25	3.3~1500	—	Purple	32 33
	Radial lead type 	UP GRADE SEPC	Super low ESR, large capacitance, miniaturization and low profile	●	●		−55°C~+105°C	2.5~16	180~2700	—	Purple	34 35
		SEQP	Guaranteed at 125°C, high voltage		●		−55°C~+125°C	4~32	6.8~1200	—	Purple	36 37
		SEP	Guaranteed for 3,000h			●	−55°C~+105°C	2.5~25	6.8~1500	—	Purple	38 39
Organic semiconductor electrolyte	Radial lead type 	SF	5mm height max.				−55°C~+105°C	4~6.3	150~220	Purple	White	40 41
		SP	Large capacitance & low ESR for audio	●	●		−55°C~+105°C	2~25	6.8~2200	Purple	White	42 43
		SC	Standard				−55°C~+105°C	6.3~30	1.0~47	Purple	White	44 45
		SA	Large capacitance, miniaturization	●			−55°C~+105°C	6.3~20	15~2200	Purple	White	46 47
		SL	Low profile				−55°C~+105°C	4~25	1.0~220	Purple	White	48 49
		SH	Long life			●	−55°C~+105°C	6.3~25	1.0~330	Purple	White	50 51
		SS	Miniaturization				−55°C~+105°C	4~20	2.2~470	Purple	White	52 53

OS-CON is an aluminum solid capacitor with high conductive polymer or organic semiconductor electrolyte material. **OS-CON** acquires low Equivalent Series Resistance (ESR), excellent noise reduction capability and frequency characteristics. In addition, **OS-CON** has a long life span and its ESR has little change even at low temperatures since the electrolyte is solid.



Features

● Low ESR obtained by using conductive polymer electrolyte

- Suitable as a decoupling capacitor, because its impedance has ideal frequency characteristics.
- Suitable as a smoothing capacitor, enabling miniaturizing switching power supplies, because it allows large ripple current.
- Suitable as a backup capacitor for the circuits that consume large current at a high speed.

● Pb-free Compliant

All the models are completely Pb-free and RoHS compliant products.

● Long life

50000h life at 85°C can be expected (SVQP, SVPD, SEQP, SH series), suitable for long-operating industrial equipments.

● Superior temperature characteristics

Its ESR has stable characteristics at a temperature from -55°C to 105°C (partly 125°C), suitable for applications used at low temperatures (under 0°C).

● Wide capacitance range from 1μF to 2700μF

An array of various series covers wide capacitance range.

● High voltage, high reliability

High reliability products have achieved the highest rated voltage 35V and the guarantee of 85°Cx85%RH (SVPD series), suitable for automotive and industrial equipments.

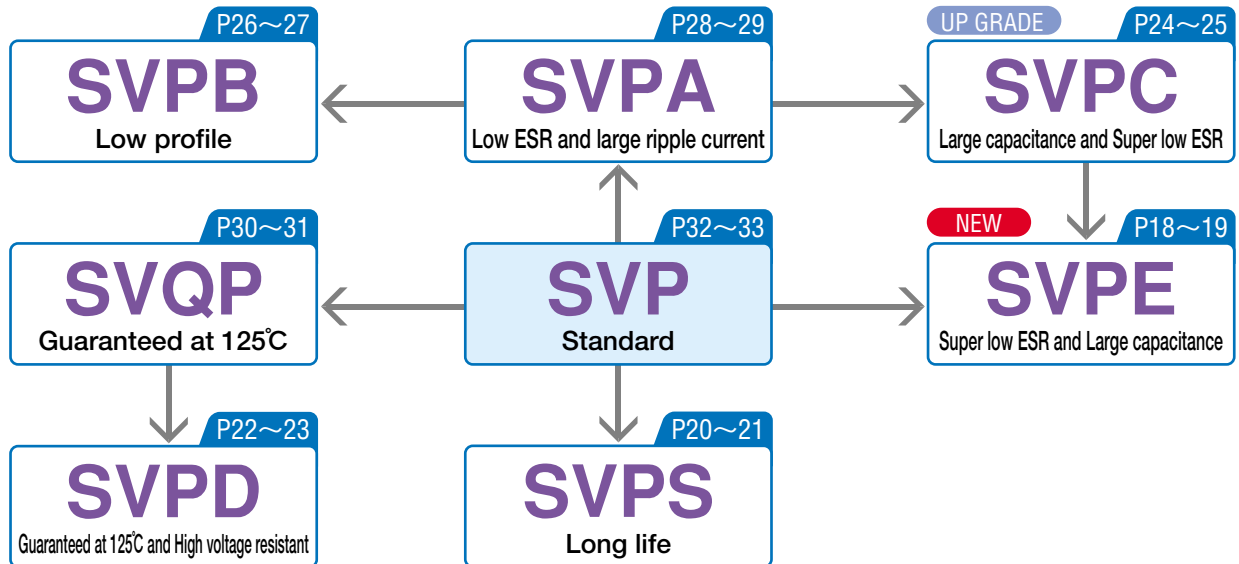
Applications

As a smoothing, backup, and bypass capacitor used in various fields such as digital equipments, household appliances, computer-related hardware, and industrial equipments.

1. System Diagram

Aluminum solid capacitors with Conductive polymer

SMD type



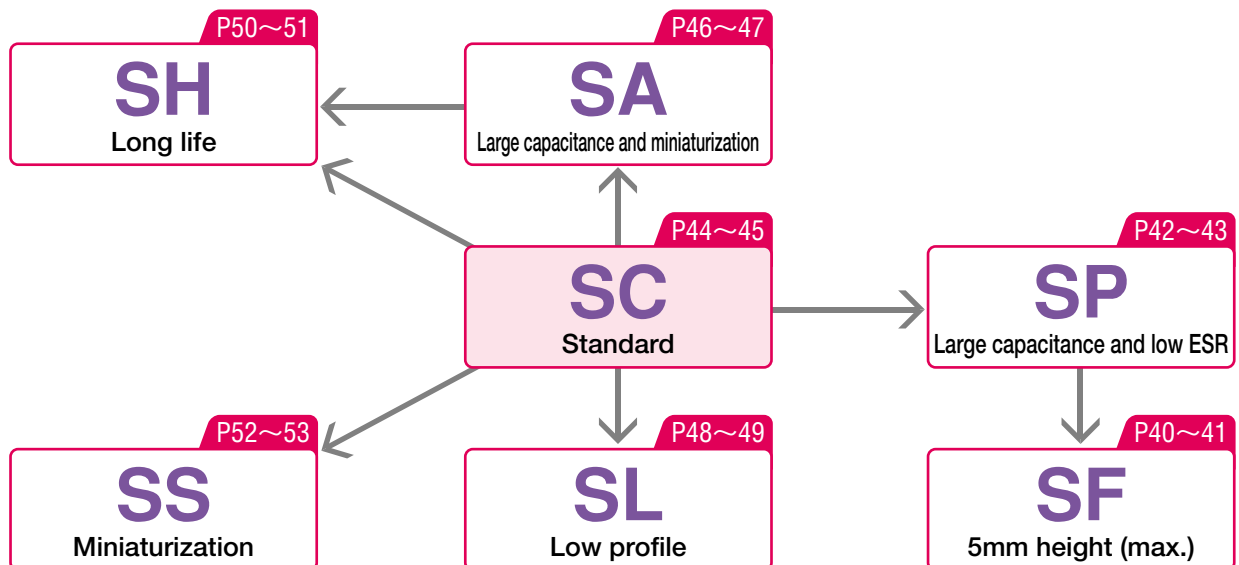
Aluminum solid capacitors with Conductive polymer

Radial lead type



Aluminum solid capacitors with Organic semiconductive electrolyte

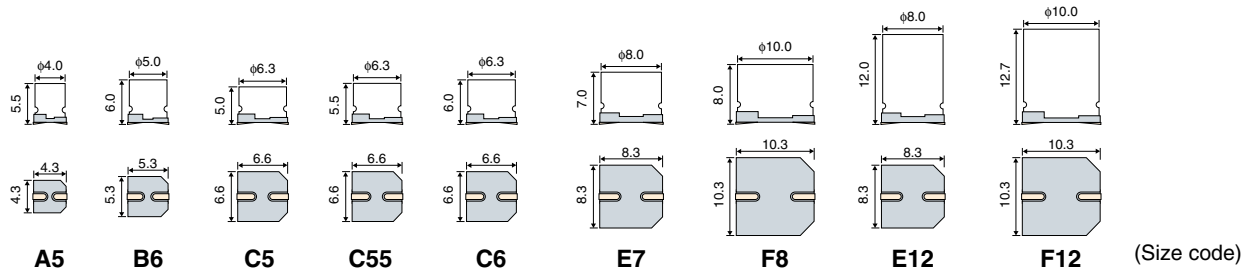
Radial lead type



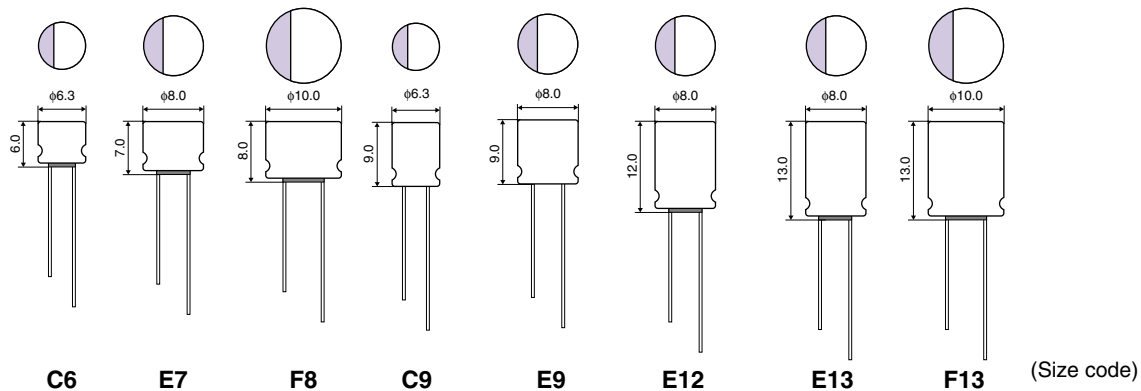
2. Sketch of Case Size

(unit : mm)

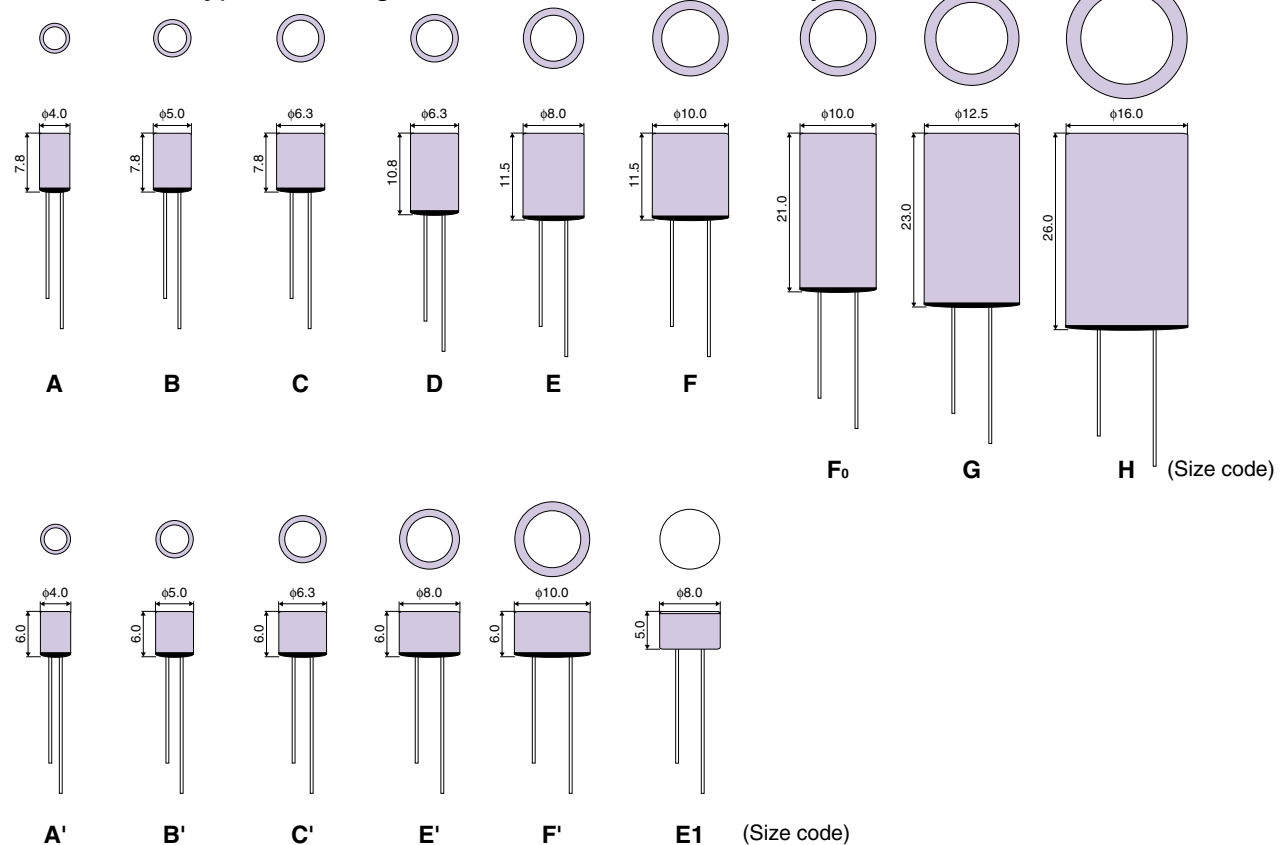
SMD type with conductive polymer electrolyte



Radial lead type with conductive polymer electrolyte



Radial lead type with Organic semiconductive electrolyte



※Profile of case size are all expressed in maximum values.

3. Size • ESR Matrix List SMD Type

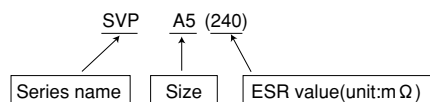
V μF	2.5	4	6.3	10
3.3				
4.7				SVP A5(240)
6.8				SVP A5(240)
8.2				
10				SVPS A5(220) SVP A5(220)
15				SVPS A5(200) SVP A5(200)
18				
22			SVPS A5(200) SVP A5(200)	
27				
33		SVPS A5(200) SVP A5(200)		SVPS B6(70) SVP B6(70)
39		SVP B6(70)		
47			SVPS B6(30) SVPA B6(30)	SVP B6(70) SVP C6(50)
56				SVPD C6(45) SVQP C6(45) SVPB C5(40) SVP C6(45)
68		SVPS B6(30) SVPA B6(30)	SVP B6(60)	SVPS C6(30) SVPC B6(23) SVPC B6(30) SVPA C6(30)
82	SVPA B6(30)		SVPB C5(40) SVQP C6(45) SVP C6(45)	
100		SVPB C5(40)	SVPC B6(30) SVPC B6(25)	SVQP C6(40) SVP C6(40)
120	SVPB C5(40)		SVPS C6(22) SVPC B6(21)	SVPA C6(22) SVPC C6(27) SVPC C6(22) SVP E7(35) SVPS E7(30) SVP E7(35) SVPS F8(30) SVP F8(30) SVPA E7(30) SVQP E7(35)
150		SVPS C6(22) SVPC B6(30) SVPC B6(23) SVPC B6(20)	SVPA C6(22) SVQP C6(40) SVP C6(40)	
180	SVPC B6(30) SVPC B6(24) SVPC B6(19) SVPA C6(20)			
220	SVP C6(23)		SVPS E7(22) SVPC C6(27) SVPC C6(15) SVPA E7(22)	SVQP E7(35) SVP E7(35) SVP F8(25)
270		SVPS E7(22) SVPA E7(22)		SVPC E7(22) SVP F8(25)
330	SVPA E7(20)	SVPS C6(27) SVPC C6(21)	SVPC C6(15) SVP E7(35)	SVPC C6(17) SVP F8(25)
390	SVPE C6(10) SVPC C6(25) SVPC C6(15)		SVPC E7(22)	
470			SVPS F8(20) SVPA F8(20)	SVP F8(25) SVP E12(15)
560	SVPC C6(16)	SVPC E7(22) SVPC E12(9)	SVP E12(13)	SVP F12(13)
680	SVPC E7(20) SVP E12(13)	SVPS F8(20) SVPA F8(20)	SVP F8(25)	
820	SVPC E12(9) SVPA F8(19)		SVPC E12(12) SVP F12(12)	
1200		SVPC E12(12)	SVP F12(12)	
1500	SVPC E12(10) SVP F12(12)	SVPC E12(12)		
2700	SVPC F12(12)			

●...Conductive polymer type

How to read the lists in P6-9

- The name, sizes and ESR values of each series are found where the voltage (V) and capacitance (μF) intersect each other. (Refer to the example.)
- Please confirm the details in the list of each series from P18 to P53.
- When you find two or more series names in one section, they have different part numbers. Please confirm the number in the Series Characteristics List of each series.

Example



Series System Diagram

Aluminum solid capacitors with Conductive polymer
Aluminum solid capacitors with Organic semiconductive electrolyte

3. Size • ESR Matrix List SMD Type

16		20		25	35	V μF
SVP A5(260)						3.3
						4.7
				SVP C6(80)		6.8
					SVPD E7(70)	8.2
		SVPA B6(40) SVP B6(120)		SVPS E7(60) SVPD C6(65) SVP E7(60)		10
SVP B6(120)		SVPB C5(45)				15
					SVPD F8(60)	18
SVPS B6(90) SVP B6(90)		SVPS C6(60) SVPB C55(35) SVPA C6(35)	SVQP C6(60) SVP C6(60)	SVPD E7(48) SVP F8(50)	SVPD E12(50)	22
		SVP C6(60)				27
SVPB C5(40)		SVP E7(45)		SVP E12(30)		33
SVPS C6(24) SVPC B6(35) SVPC B6(27) SVPA C6(35)	SVPA C6(24) SVQP C6(50) SVP C6(50)			SVPD F8(45)		39
		SVPS E7(45) SVPA E7(33)	SVQP E7(45) SVP E7(45)	SVPD E12(30)	SVPD F12(30)	47
SVP E7(45)		SVP F8(40)		SVP F12(28)		56
SVPC C6(30) SVPC C6(25)		SVP F8(40)				68
SVPS E7(30) SVPD E7(40) SVPA E7(30)	SVQP E7(40) SVP E7(40)			SVPD F12(28)		82
SVPS F8(35) SVPC C6(24)	SVP F8(35)	SVP E12(24)				100
SVPC E7(27)						120
SVPC E7(22) SVP F8(30)		SVP F12(20)				150
SVPS F8(29) SVPA F8(29) SVP F8(30)	SVP E12(20)					180
						220
SVPC E12(16)						270
SVP F12(16)						330
						390
						470
						560
						680
						820
						1200
						1500
						2700

●...Conductive polymer type

Standard sizes (Conductive polymer type) (unit : mm)

A5	φ 4.0×L5.5	E7	φ 8.0×L7.0
B6	φ 5.0×L6.0	F8	φ 10.0×L8.0
C5	φ 6.3×L5.0	E12	φ 8.0×L12.0
C55	φ 6.3×L5.5	F12	φ 10.0×L12.7
C6	φ 6.3×L6.0		

Series System Diagram

Aluminum solid capacitors with Conductive polymer
Aluminum solid capacitors with Organic semiconductive electrolyte

3. Size • ESR Matrix List Radial Lead Type

V μF	2	2.5	4	6.3	10
1					
1.5					
2.2					
3.3					
4.7					SC A(280) SL A'(400) SH A(280)
6.8				SC A(250) SL A'(350) SH A(250)	
10					SC B(150) SL B'(150) SH B(150) SS A'(350)
15				SC B(120) SL B'(120) SH B(120) SS A'(350)	
18					
22					SC C(70) SL C'(80) SS B'(150) SL C'(80)
33				SC C(70) SS B'(150)	
39					
47				SA C(60) SH C(60)	SC D(60) SL C'(70)
56					SEQP C6(45) SEP C6(45) SP C'(45)
68			SS C'(70)	SP C'(40)	SA D(50) SL E'(65) SH D(50)
82				SEQP C6(45) SL E'(65) SEP C6(45)	SP C(40)
100			SEP C6(40) SP C'(40)		SP E'(32) SL F'(60) SS D(40)
120				SP C(35)	SEQP E7(35) SEP E7(35)
150			SEQP C6(40) SEP C6(40) SP C(35) SL E'(60)	SS D(40) SEQP E7(35) SEP E7(35) SF E1(32) SP E'(30)	SA E(30) SL F'(60) SH E(30)
180					SP F'(29)
220			SEP E7(35) SF E1(30) SP D(20)	SP F'(28) SL F'(55) SP D(20)	SS E(30) SA F(27) SH F(27)
270					SEQP F8(25) SEP F8(25) SP E(18)
330			SEQP E7(35) SEP E7(35)	SP F'(24) SEQP F8(25) SEP F8(25)	SA F(25) SH F(25) SEQP E12(17) SEP E12(17) SS F(25)
390				SP E(16)	
470			SEP F8(25) SS F(25)	SEPC E9(8) SEPC E13(8) SEQP E12(15) SEP E12(15)	SP F(15)
560		SEPC C9(7) SEPC E9(8)	SEPC E9(7) SEPC E13(7) SEQP E12(13)	SEP E12(13) SP E(14) SEPC E9(7)	SEQP F13(13) SEP F13(13)
680		SEP E12(13)	SEPC E13(7) SEQP F8(25)	SEP F8(25) SEPC F13(7) SP F(13)	
820		SEPC E9(5) SEPC E9(7) SEPC E13(7)	SEPC F13(7) SP F(12)	SEQP F13(12) SEP F13(12)	
1000	SP F(11)	SEPC E9(7)	SP F(12)		
1200		SP F(12)	SEQP F13(12) SEP F13(12)		
1500		SEP F13(12)	SP Fo(8)	SEPC F13(10)	
1800	SP Fo(8)				
2200			SP G(9)	SA H(15)	
2700		SEPC F13(10)			

●...Conductive polymer type ●...Organic semiconductor type

Series System Diagram

Aluminum solid capacitors with Conductive polymer
Aluminum solid capacitors with Organic semiconductive electrolyte

3. Size • ESR Matrix List Radial Lead Type

16		20		25		30	32	V μF
				SC A(350) SL A'(450)	SH A(350)	SC A(350)		1
				SC A(300) SL A'(400)	SH A(300)	SC B(300)		1.5
SC A(280) SL A'(400)	SH A(280)	SS A'(400)		SC B(200) SL B'(250)	SH B(200)	SC B(250)		2.2
SC A(280) SL A'(400)	SH A(280)	SS A'(400)		SC B(200) SL B'(250)	SH B(200)	SC C(200)		3.3
SC B(180) SL B'(250)	SH B(180) SS A'(400)	SS B'(250)		SC C(100) SL C'(100)	SH C(100)	SC D(120)		4.7
SL B'(180) SH B(150) SS A'(400)		SS B'(180)		SEP C6(80) SP C'(60) SC C(100)	SL C'(100) SH C(100)	SC D(120)	SEQP E7(100)	6.8
SL C'(100) SS B'(150)		SS C'(100)		SEP E7(60) SP C(55) SC C(90)	SH C(90)	SC E(110)		10
SC C(90) SL C'(100)	SS B'(150)	SA C(90) SH C(90)	SS C'(100)	SC D(70) SL E'(75)	SH D(70)		SEQP F8(80)	15
				SP D(40)			SEQP E12(50)	18
SC D(70)		SEQP C6(60) SEP C6(60) SP C'(50)	SA C(70) SH C(70) SS C'(100)	SEP F8(50) SC E(40) SL F'(70)		SC F(80)		22
SC D(70) SP C'(50) SA C(70)	SH C(70) SS C'(100)	SEP E7(45) SP C(45) SA D(70)	SH D(70)	SEP E12(30) SP E(30) SC F(35)				33
SEQP C6(50)	SEP C6(50)							39
SP C(45) SA D(60) SL E'(70)	SH D(60)	SEQP E7(45) SEP E7(45) SP E'(36) SEP F8(40)	SA E(40) SH E(40) SS D(60)	SC F(35)				47
				SEP F13(28) SP F(25)				56
SP E'(34) SL F'(65) SS D(50)		SEQP F8(40) SEP F8(40) SP F'(34)	SP D(30) SA E(36) SH E(36)					68
SEQP E7(40)	SEP E7(40)							82
SEPC C6(24) SEPC C9(10) SP F'(32)	SP D(25) SA E(30) SH E(30)	SEQP E12(24) SEP F8(35) SEP E12(24)	SA F(30) SH F(30) SS E(30)					100
		SP E(24)						120
SEQP F8(30) SEP F8(30) SA F(28) SH F(28)		SEQP F13(20) SEP F13(20) SS F(30)						150
SEQP E12(20) SEPC E9(10)	SEPC E12(16) SEP E12(20) SP E(20)	SP F(20)						180
								220
SEPC E12(11) SP F(18)								270
SEQP F13(16) SEP F13(16)								330
								390
SEPC F13(10) SA G(20)								470
								560
								680
								820
SA H(15)								1000
								1200
								1500
								1800
								2200
								2700

●...Conductive polymer type ●...Organic semiconductor type

Standard sizes (Conductive polymer type) (unit : mm)

C6	φ 6.3×L6.0	E9	φ 8.0×L9.0
C9	φ 6.3×L9.0	E12	φ 8.0×L12.0
E7	φ 8.0×L7.0	E13	φ 8.0×L13.0
F8	φ 10.0×L8.0	F13	φ 10.0×L13.0

Standard sizes (Organic semiconductor type)

(unit : mm)

A	φ 4.0×L7.8	E	φ 8.0×L11.5	H	φ 16.0×L26.0	E'	φ 8.0×L6.0
B	φ 5.0×L7.8	F	φ 10.0×L11.5	A'	φ 4.0×L6.0	F'	φ 10.0×L6.0
C	φ 6.3×L7.8	F0	φ 10.0×L21.0	B'	φ 5.0×L6.0	E1	φ 8.0×L10.0
D	φ 6.3×L10.8	G	φ 12.5×L23.0	C'	φ 6.3×L6.0		

Please read the following in order to take full advantage of your OS-CON performance and to ensure the most stable quality possible.

Please confirm the use environment and the circuit conditions, then use your OS-CON within the specifications.

! Precautions for circuit designing

Crucial precautions [Important]

1. Prohibited circuits

- (a) OS-CON leakage current may become larger as the following conditions.
 - (1) Soldering
 - (2) High temperature no-load test, high temperature and high humidity no-load test, rapidly changing temperature test, etc.
 - (b) Avoid the use of OS-CON in the following type of circuits because leakage current may increase.
 - (1) High-impedance circuits
 - (2) Coupling circuits
 - (3) Time constant circuits
 - (4) Other circuits that are significantly affected by leakage current
- ※ If you plan to use 2 or more OS-CONs in a series connection, please contact us before use.

2. Polarity

OS-CON is a polarized solid aluminum electrolytic capacitor with positive and negative electrodes.

Please confirm the polarity prior to use.

Using reversed voltage may cause leakage current increased or life span decreased.

3. Over rated voltage

Do not apply voltages exceeding the full rated voltage.

4. Operating temperature and ripple current

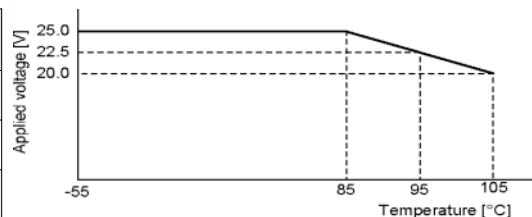
- (a) Operating temperature (ambient of OS-CON) must be under the category temperature range of specification.
- (b) Do not apply currents that excess the rated ripple current.

When excessive ripple current is applied, the OS-CON may result in shorter life due to the internal heat increase.

In case the frequency is less than 100kHz, the ripple current is need to be used under frequency coefficient.

5. Applied voltage on design

	Operating environmental Temperature	Applied voltage
25V products except for SVPD	85°C below	Less than the rated voltage
	85°C above	Applied the voltage shown right figure
All except for the above	—	Less than the rated voltage



- (a) Sum of DC voltages and ripple voltages peak value must not exceed the full rated voltage.
- (b) Do not apply reverse voltages to your OS-CON.

Please contact us when there is a concern that circuit operation may cause reverse voltage.

6. Sudden charge and discharge

An excessive surge current by sudden charge or discharge may result in a short circuit or a large leakage current. Protection circuits are recommended to retain high reliability in case of the following conditions.

- (1) The surge current value exceeds 10A
- (2) The value exceeds 10 times of the rated ripple current
- ※ When you measure leakage current, a protection resistor of approximately 1k Ω must be inserted to the circuit before charge and discharge.

7. Failure and life-span

The failure rate is 0.5% / 1000h (with a 60% reliability standard) based on JIS C 5003.

The mainly failure modes are as follows.

7-1. Contingency failure

The main causes of failure are thermal stresses cause by the soldering or thermal use environment, along with heat stresses, electrical stresses or mechanical stresses. The most common failure mode is a short circuit.

(a) Phenomenon after a short circuit

(1) Organic semiconductive type (resin sealing)

- In case of a short circuit, if the pass-through current is 3A or less on ϕ 10 and 1A or less on ϕ 6.3, the **OS-CON** becomes heated but no effects are visible even when the current is continuously carried.
- If the short circuit currents exceed the mentioned value above.

The temperature inside will increase and the internal press raise. The liquefied organic semiconductor and odorous gas are released from the space of sealant. In this case, keep your face and hands away from the area.

(2) Conductive polymer type (rubber sealing)

- In case of a short circuit, if the pass-through current is 1A or less on ϕ 10, 0.5A or less on ϕ 8 and 0.2A or less on ϕ 6.3, the **OS-CON** becomes heated, but no effects are visible even when the current is continuously carried.
- If the short circuit currents exceed the mentioned value above.

The temperature inside the **OS-CON** will increase. The rubber sealing is turned over and odorous gas is released. In this case, keep your face and hands away from the area.

(b) In case a short circuit occurs, ensure safety by fully considering the followings.

- (1) If odorous gas is released, turn off the main power of the equipment.
- (2) It may take a few seconds to a few minutes before the organic semiconductor liquefies and an odorous gas produces by the situation. Increase safety by using in conjunction with a protective circuit.
- (3) If the gas comes in contact with eyes, rinse immediately. If the gas is inhaled, gargle immediately.
- (4) Do not lick the electrolyte. If the electrolyte comes in contact with skin, wash it off with soap immediately.
- (5) **OS-CON** contains combustible substances. In case a large current continues to flow after a short circuit, in the worst case, the shorted-out section may ignite. For safety, install a redundant circuit or a protective circuit, etc.

7-2. Wear-out failure (life-span)

When life span exceeded the specified guarantee time of Endurance and Damp heat, electrolyte might insulate and cause electric characteristic changed. This is called an open circuit.

The electric characteristics of capacitance and ESR may possibly change within the specified range in specifications when it is used under the condition of the rated voltage, electric and mechanical performance. Please note it when design.

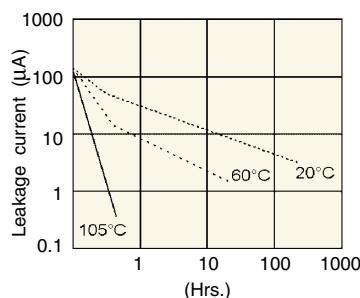
Other precautions

1. Leakage current

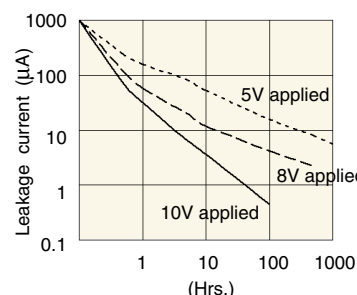
Mechanical stress may cause OS-CON leakage current increased.

In such a case, leakage current will gradually decrease by applying voltage within the category voltage and the upper category temperature. Then, self-healing speed of leakage current is faster when it is near to the upper category temperature and the category voltage.

OS-CON leakage current restoration characteristics
10 μ F/16V (16V DC applied)



OS-CON leakage current restoration characteristics
33 μ F/10V (Ambient temperature: 65°C)
(Measured voltage: 10V)



*A sample that had stress intentionally applied to make the leakage current larger was used to make leakage current recovery easy to understand.

2. Capacitor insulation

Be sure to completely separate the case, negative lead terminal, positive lead terminal and PC board patterns with each other as follows.

- Insulation in the marking sleeve and the laminate resin is not guaranteed.
- The space between the case and the negative electrode terminal is not insulated and has some resistance.

3. Operating environmental restrictions

Do not use the OS-CON in the following environments.

- Places where water, salt water or oil can directly fall on it, and places where condensation may form.
- Places filled with noxious gas (hydrogen sulfide, sulfurous acid, nitrous acid, chlorine, ammonia, etc.).
- Places susceptible to ozone, ultraviolet rays and radiation.

4. PCB design

- Avoid locating heat-generating components around the OS-CON and on the underside of the PC board.
- For the surface mount capacitor, design the copper pads on the PC board in according with the recommended land pattern or dimensions in the series specifications.
- For radial capacitor, design the terminal pitch and hole size after conforming the dimensional tolerance in the series specifications.

5. Parallel connection

A large amount of ripple current may be applied to the OS-CON when it is used in parallel with another capacitor. Carefully select the type of capacitor.

6. Others

Design circuits after checking the following items.

- Electric characteristics are affected by temperature or frequency fluctuations. Design circuits after checking the changes.
- When mounting an OS-CON on a double-sided PC board, extra PC board holes or the through holes for connecting the front and back of the PCB must not exist underneath the OS-CON.

Precautions for mounting on-board

1. Considerations when soldering

- (a) The soldering conditions as soldering iron, flow soldering, reflow soldering should be under the range prescribed in specifications.
- (b) If the specifications are not followed, there is a possibility of the cosmetic deflection, the intensive increase of leakage current or the capacitance reduction.
- (c) Soldering heat stress to OS-CON varies depending on temperature, duration time, mounting condition as size, material and component population of PC board. Please check the heat durability in your actual soldering condition before mass use.

2. Things to be noted before mounting

- (a) Do not reuse OS-CONs that have been assembled in a set and energized. Excluding OS-CONs that have been removed for measuring electrical characteristics during a periodic inspection, OS-CONs cannot be reused.
- (b) Leakage current may increase when OS-CONs are stored for long term. In this case, we recommend that you apply the rated voltage for 1 hour at 60°C ~ 70°C with a resistor load of 1kΩ.

3. Mounting -1

- (a) Mount after checking the capacitance and the rated voltage.
- (b) Do not drop OS-CON on the floor and do not use it that is dropped.
- (c) Do not mount OS-CON that is deformed.

4. Mounting -2

- (a) When an automatic inserter is used to clinch the OS-CON lead terminal, make sure it is not set too strong.
- (b) Be careful to the stock force that can be produced by absorbers, product checkers and centers on automatic inserters and installers.
- (c) Do not apply excessive external force to the lead terminal or the OS-CON itself.

5. Soldering with a soldering iron

- (a) Soldering condition should be under the following ranges.

	Soldering iron temperature	time
Soldering condition	400±10°C	within 5s.

※ Refer to item 1. Considerations when soldering

- (b) When the lead terminal for radial lead type must be processed because the lead pitch and the PCB holes in spacing do not match, process it without any stresses to OS-CON before soldering.
- (c) Solder without any excessive stresses to OS-CON itself.
- (d) When an OS-CON has been soldered once and needs to be removed, remove it after the solder has been completely melted.
- (e) Do not let the tip of the soldering iron touch the OS-CON itself.

6. Flow soldering

(a) Soldering condition should be under the following ranges.

Recommended flow soldering condition

	Temperature	Time	Flow number
Preheating	120°C or less (ambient temperature)	120 sec. or less	1 time
Soldering conditions	260 + 5°C or less	10 + 1 sec. or less	2 times or less ※1

※ 1 When soldering 2 times, immersion time should be 10 + 1 sec. or less.

※ 2. Refer to item 1. Considerations when soldering

(b) Do not apply flow soldering to SMD type.

(c) Do not solder **OS-CON** itself by submerging it in melted solder. Solder the opposite side that the **OS-CON** is mounted on.

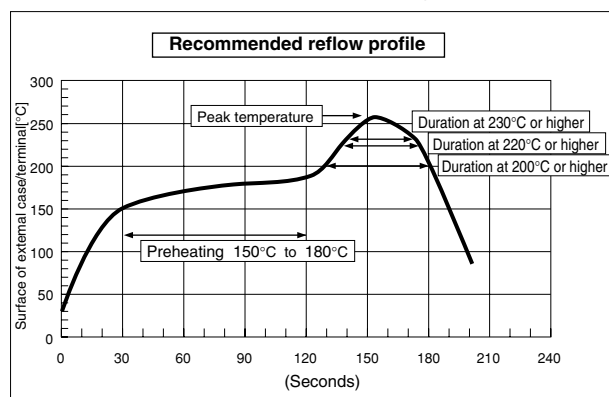
(d) Note that flux does not adhere to anywhere except the lead terminal.

(e) Note that other components do not fall over and touch the **OS-CON** when soldering.

7. Reflow soldering

(a) Soldering condition should be under the following ranges.

Recommended reflow soldering condition



Series	SVP, SVQP, SVPA, SVPB, SVPC, SVPD, SVPS, SVPE Series	
Item		
Peak temperature (MAX.)※	250°C	260°C
Preheat	150°C to 180°C 90 ± 30 sec.	
200°C over time (MAX.)	60 sec.	60 sec.
220°C over time (MAX.)	50 sec.	50 sec.
230°C over time (MAX.)	40 sec.	40 sec.
Reflow number	twice or less	Only 1 time

※ All temperatures are measured on the topside of the Al-can and terminal surface.

(b) Do not apply reflow soldering to Radial Lead type.

(c) Please contact SANYO for setting VPS condition.

8. Handling after soldering

Do not subject the **OS-CON** to excessive stress as follows.

(a) Do not tilt, bend or twist **OS-CON**.

(b) Do not move the PCB with catching **OS-CON** itself.

(c) Do not dump the **OS-CON** with objects.

(d) When stacking PCBs, make sure that the **OS-CON** does not touch other PCBs or components.

9. Cleaning PCB

Check the following items before washing PC board with these detergents: high quality alcohol-based cleaning fluid such as Pine- α ST-100S, clean thru 750H, 750L, 710M, 750K or Techno Care FRW 14 through 17 or detergents including substitute freon as AK-225AES or IPA.

- (a) Use immersion or ultrasonic waves to clean within 2 minutes on Polymer conductive type and within 5 minutes on Organic semiconductive type.
- (b) The temperature of the cleaning fluid should be less than 60°C.
- (c) Watch the contamination of the detergent as conductivity, pH, specific gravity, water content, etc.
- (d) Do not store the **OS-CON** in a location subject to gases from the cleaning fluid or in an airtight container after cleaning.
- (e) Dry the PCB or **OS-CON** with hot air that should be less than the maximum operating temperature.
- (f) Please note that Indication may disappear when rubbing print side after washing as a cleaner.
- (g) Please contact SANYO for details about detergents, cleaning methods and about detergents other than those listed above.

10. Fixatives and coating materials

- (a) Select the appropriate covering and sealant materials for **OS-CONs**. In particular, make sure the fixative, coating and thinner do not contain acetone.
- (b) Before applying a fixative or coating, completely remove any flux residue and foreign matter from the area where the board and **OS-CON** will be jointed together.
- (c) Allow any detergent to dry before applying the fixative or coating.
- (d) Please contact SANYO for fixative and coating heat curing conditions.

! Precautions for storage and disposal

1. Storage conditions

- (a) Store **OS-CON**s in a location that is not subject to direct sunlight and that has lower temperature and lower humidity. Store at a temperature between 5 to 35°C, with humidity of 75%RH or less.
- (b) **OS-CON** sets the storage period to prevent the increase of leakage current through the long-term storage before opening. When make a long-term storage, please storage its as follows.
- (c) Open the bags just before mounting and use up all products once opened. For keeping a good solderability, store the **OS-CON** as follows.

		Before unseal	After seal
SMD type ※1		Within 6 months after delivery	Within 30 days from opening (Packaged with carrier tape)
Radial lead type	Bag packing product	Within 1 year after delivery	Within 7 days from opening
	Taping product	Within 6 months after delivery	

※ The JEDEC J-STD-020 Rve.C standard is not applicable.

- (d) Store in a location free from direct contact with water, salt spray or oil spray and high humidity.
- (e) Store in a location where the **OS-CON** is not exposed to noxious gas as hydrogen sulfide, sulfurous acid, nitrous acid, chlorine, ammonia, etc.
- (f) Store in a location where the **OS-CON** is not exposed to ozone, ultraviolet radiation, or other radiation.

2. Disposal

- (a) **OS-CON** comprises solid organic compounds, various metals, resin, rubber, etc. Treat it as industrial waste when disposing of it.
- (b) In case of disposing a large amount of **OS-CON**, SANYO can dispose on behalf.

1. Measures for RoHS Directive

OS-CON complies with RoHS directive of 2002/95/EC.

Regulated substance
Cadmium and Cadmium Compounds
Lead and Lead Compounds
Mercury and Mercury Compounds
Hexavalent Chromium Compounds
Polybrominated Biphenyls (PBBs)
Polybrominated Diphenyl ethers (PBDEs)

2. Measure for Pb-free

OS-CON is completely Pb-free products including any materials of the sub-components and internal connections.
(Corresponding to Phase 3 of JEITA)

3. Measurement of OS-CON

		Measures status
Polymer conductive type	RoHS directive	Already
	Pb-free	Already
Organic semiconductive type	RoHS directive	Already
	Pb-free	Already

SVPE Series

Super low ESR

Large capacitance

The SVPE series capacitor has lower ESR than SVPC series.
Adopt this series to reduce the size of equipment and circuits.
This product can support lead free-reflow.(※2).



Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table1		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table1		
ESR	100KHz to 300KHz	Less than or equal to the value of Table1		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95% RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

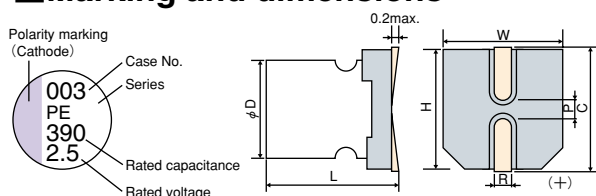
※1 When measured values are questionable, measure after voltage processing mentioned below.

Voltage processing: Apply voltage for 120 minutes at 105°C.

※2 Refer to P14 for reflow soldering conditions.

Marking and dimensions

(unit : mm)



Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1

Size List

RV : Rated voltage

(SV) : Surge voltage (Room temperature)

μF	RV (SV)
390	2.5 (3.3)
	C6

※For the minimum packing quantity, please refer to page 57.

■Table1 SVPE Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μ F)	ESR ($m\Omega$) (max.)		Rated ripple current 100kHz (mA _{RMS}) at 105°C※2	Tangent of loss angle (max.)	Leakage current (μ A) (max.)※1
				100kHz	300kHz ※3			
C6	2R5SVPE390M	2.5	390	10	9	3870	0.12	500

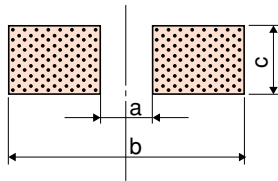
※1 After 2 minutes.

※2 at 105°C.

※3 The ESR value at 300kHz is a reference one.

■Recommended land pattern dimension of PWB

(unit : mm)



Size Code	a	b	c
C6	2.1	9.1	1.6

Frequency coefficient for ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.3	0.7	1

SVPS Series

Long Life

The SVPS series has longer lifespan than the SVP series. They are a good choice to extend the life of flat panel television sets and others.

Lead free-reflow is supported.(※2).



Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table2		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table2		
ESR	100KHz to 300KHz	Less than or equal to the value of Table2		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 5,000h, Rated voltage applied (25V→20V applied)	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95% RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

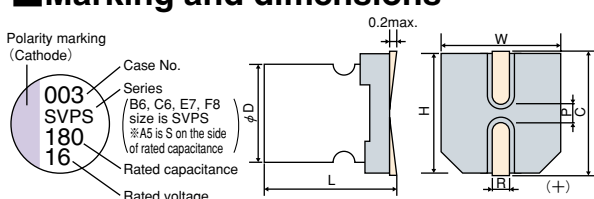
※1 When measured values are questionable, measure after voltage processing mentioned below.

Voltage processing: Apply voltage for 120 minutes at 105°C. The voltage to be applied is the rated voltage for 4-20V products, and 20V for 25V products.

※2 Refer to P14 for reflow soldering conditions.

Marking and dimensions

(unit : mm)



Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
A5	4.0	5.4	4.3	4.3	5.0	0.6 to 0.8	1.0
B6	5.0	5.9	5.3	5.3	6.0	0.6 to 0.8	1.4
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2
F8	10.0	7.9	10.3	10.3	11.0	0.6 to 0.8	4.6

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23)	25 (25)
10				A5			E7
15				A5			
22			A5		B6	C6	
33	A5			B6			
39					C6		
47			B6			E7	
68	B6			C6			
82					E7		
100					F8		
120			C6				
150	C6			E7, F8			
180					F8		
220			E7				
270	E7						
330				F8			
470			F8				
680	F8						

※For the minimum packing quantity, please refer to page 57.

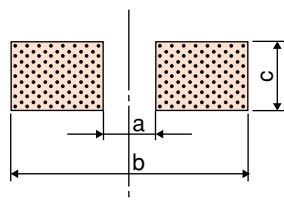
■Table2 SVPS Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current 100kHz(mArms)※2	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
A5	10SVPS10M	10	10	220	700	0.10	50
	10SVPS15M	10	15	200	740	0.10	75
	6SVPS22M	6.3	22	200	740	0.12	69.3
	4SVPS33M	4	33	200	740	0.15	66
B6	16SVPS22M	16	22	90	1060	0.10	176
	10SVPS33M	10	33	70	1100	0.12	165
	6SVPS47M	6.3	47	30	1970	0.12	300
	4SVPS68M	4	68	30	1970	0.12	300
C6	20SVPS22M	20	22	60	1450	0.10	88
	16SVPS39M	16	39	24	2460	0.12	300
	10SVPS68M	10	68	30	2200	0.12	300
	6SVPS120M	6.3	120	22	2570	0.12	300
	4SVPS150M	4	150	22	2570	0.12	300
E7	25SVPS10M	25	10	60	1500	0.10	125
	20SVPS47M	20	47	45	1890	0.12	188
	16SVPS82M	16	82	30	2760	0.12	262
	10SVPS150MX	10	150	30	2760	0.12	500
	6SVPS220M	6.3	220	22	3220	0.12	500
	4SVPS270M	4	270	22	3220	0.12	500
F8	16SVPS100M	16	100	35	2670	0.12	320
	16SVPS180M	16	180	29	3430	0.12	576
	10SVPS150M	10	150	30	3020	0.12	300
	10SVPS330M	10	330	24	3770	0.12	660
	6SVPS470M	6.3	470	20	4130	0.12	592
	4SVPS680M	4	680	20	4130	0.12	544

※1 After 2 minutes

※2 The surface temperature of aluminum case top must not exceed 105°C. A rise in temperature due to self-heating by ripple current should be factored in.

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
A5	1.0	6.2	1.6
B6	1.4	7.4	1.6
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9
F8	4.3	13.1	1.9

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVPD Series

Guaranteed at 125°C

Rated 35V max.

85°C×85% guaranteed, Rated 35V

The SVQP series guaranteed 125°C high voltage resistance was improved to a rated maximum of 35V. This product is very reliable, guaranteeing 85°C×85% performance. Suitable for use in smoothing circuits of vehicle-mounted equipment, industrial equipment, etc. This product can support lead free-reflow.(※2).



Specifications

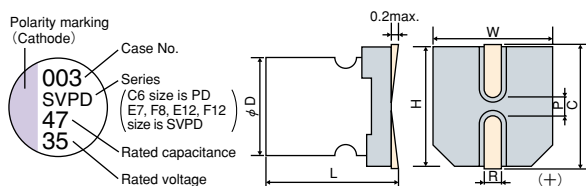
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +125°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table3		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table3		
ESR	100KHz to 300KHz	Less than or equal to the value of Table3		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+125°C	Z / Z 20°C	0.75 to 1.25
Endurance	125°C, 2,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		ESR	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	85°C, 85 to 90% RH, 1,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		ESR	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 125°C.

※2 Refer to Page 14 for reflow soldering conditions.

Marking and dimensions

(unit : mm)



Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2
F8	10.0	7.9	10.3	10.3	11.0	0.6 to 0.8	4.6
E12	8.0	11.9	8.3	8.3	9.0	0.8 to 1.1	3.2
F12	10.0	12.6	10.3	10.3	11.0	0.8 to 1.1	4.6

Size List

RV : Rated voltage
(SV) : Surge voltage (125°C)

μF	RV (SV)	10.0 (12)	16.0 (18.4)	25.0 (29.0)	35.0 (40.0)
8.2					E7
10				C6	
18					F8
22				E7	E12
39				F8	
47				E12	F12
56	C6				
82			E7	F12	

※For the minimum packing quantity, please refer to page 57.

■Table3 SVPD Series Characteristics List

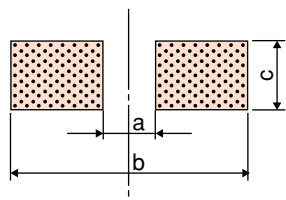
Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current	Allowable ripple current	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
					100kHz	(mA rms) ※2		
					105℃ < Tx ≤ 125℃	Tx ≤ 105℃		
C6	25SVPD10M	25	10	65	474	1500	0.10	50
	10SVPD56M	10	56	45	538	1700	0.12	112
E7	35SVPD8R2M	35	8.2	70	400	1300	0.10	57
	25SVPD22M	25	22	48	580	1835	0.10	110
	16SVPD82M	16	82	40	670	2120	0.12	262
F8	35SVPD18M	35	18	60	550	1800	0.10	126
	25SVPD39M	25	39	45	664	2100	0.10	195
E12	35SVPD22M	35	22	50	700	2300	0.12	154
	25SVPD47M	25	47	30	943	2980	0.12	235
F12	35SVPD47M	35	47	30	1150	3650	0.12	329
	25SVPD82M	25	82	28	1202	3800	0.12	410

※1 After 2 minutes

※2 Tx : Ambient temperature

SVPD

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9
F8	4.3	13.1	1.9
E12	2.8	11.1	1.9
F12	4.3	13.1	1.9

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVPC Series

Large capacitance

Super low ESR

The SVPC series capacitor has larger capacitance than SVPA series.

Adopt this series to reduce the size of equipment and circuits.
This product can support lead free-reflow. (※2).



Specifications

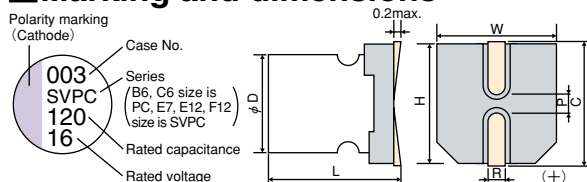
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M: ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table4		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table4		
ESR	100KHz	Less than or equal to the value of Table4		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10% (±15% for 2.5V)	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 105°C.

※2 Refer to Page 14 for reflow soldering conditions.

(unit : mm)

Marking and dimensions



Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
B6	5.0	5.9	5.3	5.3	6.0	0.6 to 0.8	1.4
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2
E12	8.0	11.9	8.3	8.3	9.0	0.8 to 1.1	3.2
F12	10.0	12.6	10.3	10.3	11.0	0.8 to 1.1	4.6

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	2.5 (3.3)	4 (5.2)	6.3 (8.2)	10.0 (12)	16.0 (18.4)
39					B6	B6
68					B6	C6
100				B6	C6	C6
120				B6	C6	E7
150			B6			E7
180	B6					
220				C6		
270					E7	E12
330			C6	C6		
390	C6			E7		
560	C6		E7, E12			
680	E7					
820	E12			E12		
1200			E12			
1500	E12		E12			
2700	F12					

※For the minimum packing quantity, please refer to page 57.

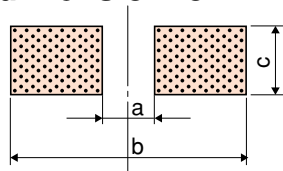
■Table4 SVPC Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR (mΩ) (max.)		Rated ripple current 100kHz (mA _{rms}) at 105°C	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
				100kHz	300kHz ※2			
B6	16SVPC39M	16	39	35	30	1820	0.12	300
	16SVPC39MV	16	39	27	23	2350	0.12	300
	10SVPC68M	10	68	30	26	1970	0.12	300
	10SVPC68MV	10	68	23	20	2540	0.12	300
	6SVPC100M	6.3	100	30	26	1970	0.12	300
	6SVPC100MY	6.3	100	25	21	2150	0.12	300
	6SVPC120MV	6.3	120	21	18	2660	0.12	300
	4SVPC150M	4	150	30	26	1970	0.12	300
	4SVPC150MY	4	150	23	20	2240	0.12	300
	4SVPC150MV	4	150	20	17	2730	0.12	300
	2R5SVPC180M	2.5	180	30	26	1970	0.12	300
	2R5SVPC180MY	2.5	180	24	20	2200	0.12	300
	2R5SVPC180MV	2.5	180	19	16	2800	0.12	300
C6	16SVPC68M	16	68	30	26	2200	0.12	300
	16SVPC68MV	16	68	25	22	2440	0.12	300
	16SVPC100M	16	100	24	23	2490	0.12	300
	10SVPC120M	10	120	27	23	2320	0.12	300
	10SVPC120MV	10	120	22	19	2600	0.12	300
	6SVPC220M	6.3	220	27	23	2320	0.12	300
	6SVPC220MV	6.3	220	15	13	3160	0.12	300
	6SVPC330M	6.3	330	17	15	3390	0.12	415
	4SVPC330M	4	330	27	23	2320	0.12	300
	4SVPC330MY	4	330	21	18	2630	0.12	300
	4SVPC330MV	4	330	15	13	3160	0.12	300
	2R5SVPC390M	2.5	390	25	22	2410	0.12	300
	2R5SVPC390MV	2.5	390	15	13	3160	0.12	300
	2R5SVPC560M	2.5	560	16	14	3500	0.12	300
E7	16SVPC120M	16	120	27	23	2900	0.12	500
	16SVPC150M	16	150	22	21	3220	0.12	500
	10SVPC270M	10	270	22	19	3220	0.12	500
	6SVPC390M	6.3	390	22	19	3220	0.12	491
	4SVPC560M	4	560	22	19	3220	0.12	500
	2R5SVPC680M	2.5	680	20	17	3370	0.12	500
E12	16SVPC270M	16	270	16	14	4070	0.15	864
	6SVPC820M	6.3	820	12	10	4700	0.15	1033
	4SVPC560MX	4	560	9	8	5380	0.15	500
	4SVPC1200M	4	1200	12	10	4700	0.15	960
	4SVPC1500M	4	1500	12	10	4700	0.15	1200
	2R5SVPC820M	2.5	820	9	8	5380	0.15	500
	2R5SVPC1500M	2.5	1500	10	9	5150	0.15	750
F12	2R5SVPC2700M	2.5	2700	12	10	5070	0.15	1350

※1 After 2 minutes

※2 The ESR value in 300kHz is a reference one.

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
B6	1.4	7.4	1.6
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9
E12	2.8	11.1	1.9
F12	4.3	13.1	1.9

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVPB Series

Low profile

This is a low profile series based on the SVPA series. Suitable for miniaturizing devices and circuits.

This product can support lead free-reflow(※2).



Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M :±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table5		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table5		
ESR	100KHz to 300KHz	Less than or equal to the value of Table5		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
		ΔC/C	Within ±20% (±30% for C5 size)	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
Endurance	105°C, 1,000h, Rated voltage applied	Leakage current	Below an initial standard	
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Damp heat (Steady state)	60°C, 90 to 95% RH, 1,000h, No-applied voltage	ΔC/C	Within ±10% (±20% for C5 size)	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10% (±20% for C5 size)	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 105°C.

※2 Refer to Page 14 for reflow soldering conditions.

Marking and dimensions

Polarity marking (Cathode)		(unit : mm)						
Case No.	Series (PB)	Rated capacitance	Rated voltage	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2
003	PB	56	10	6.3	4.9	6.6	6.6	7.3
003	PB	56	10	6.3	5.4	6.6	6.6	7.3

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

RV (SV)	2.5 (3.3)	4.0 (5.2)	6.3 (8.2)	10.0 (12)	16.0 (18.4)	20.0 (23.0)
15						C5
22						C55
33					C5	
56				C5		
82			C5			
100		C5				
120	C5					

※For the minimum packing quantity, please refer to page 57.

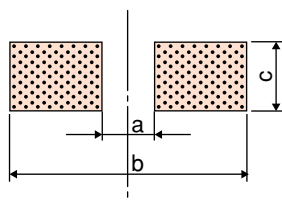
■Table5 SVPB Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current 100kHz (mA _{RMS}) at 105°C	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
C5	20SVPB15M	20	15	45	2000	0.12	120
	16SVPB33M	16	33	40	1670	0.12	211
	10SVPB56M	10	56	40	1670	0.12	224
	6SVPB82M	6.3	82	40	1670	0.12	207
	4SVPB100M	4	100	40	1670	0.12	160
	2R5SVPB120M	2.5	120	40	1670	0.12	120
C55	20SVPB22M	20	22	35	2000	0.12	88

※1 After 2 minutes

- The C5 size is also available upon request as a radial lead type. Please contact us if this type is required. Maximum height for radial lead types is 4.5 mm.
- The C55 size is also available upon request as 4V and 6.3V products.

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
C5	2.1	9.1	1.6
C55	2.1	9.1	1.6

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVPA Series

Low ESR

Large ripple current

This is a low ESR series based on the SVP series. Suitable for miniaturizing devices and circuits.

This product can support lead free-reflow(※2).



Specifications

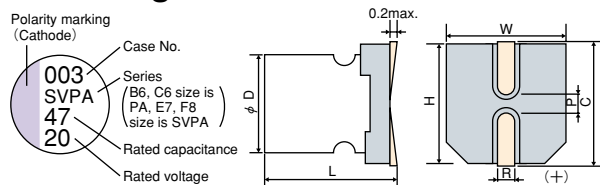
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table6		
Leakage current ※ 1	After 2 minutes	Less than or equal to the value of Table6		
ESR	100KHz	Less than or equal to the value of Table6		
Endurance	105°C, 2,000h, Rated voltage applied	-55°C	Z / Z _{20°C}	0.75 to 1.25
		+105°C	Z / Z _{20°C}	0.75 to 1.25
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	Leakage current	Below an initial standard	
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※ 2	VPS (230°C X 75s)	ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※ 1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 105°C.

※ 2 Refer to Page 14 for reflow soldering conditions.

Marking and dimensions

(unit : mm)



Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
B6	5.0	5.9	5.3	5.3	6.0	0.6 to 0.8	1.4
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2
F8	10.0	7.9	10.3	10.3	11.0	0.6 to 0.8	4.6

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	2.5 (3.3)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23.0)
10							B6
22							C6
39						C6	
47				B6			E7
68			B6		C6		
82	B6					E7	
120				C6			
150			C6		E7		
180	C6					F8	
220				E7			
270			E7				
330	E7				F8		
470				F8			
680			F8				
820	F8						

※ For the minimum packing quantity, please refer to page 57.

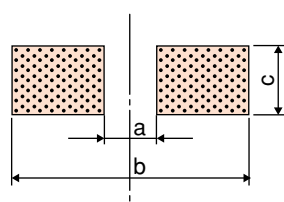
■Table6 SVPA Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR (mΩ) (max.)		Rated ripple current 100kHz (mA) at 105°C	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
				100kHz	300kHz ※2			
B6	20SVPA10M	20	10	40	35	1700	0.12	80
	6SVPA47MAA	6.3	47	30	26	1970	0.12	300
	4SVPA68MAA	4	68	30	26	1970	0.12	300
	2R5SVPA82MAA	2.5	82	30	26	1970	0.12	300
C6	20SVPA22M	20	22	35	31	2040	0.12	88
	16SVPA39MAA	16	39	35	31	2040	0.12	300
	16SVPA39MAAY	16	39	24	20	2460	0.12	300
	10SVPA68MAA	10	68	30	26	2200	0.12	300
	6SVPA120MAA	6.3	120	22	19	2570	0.12	300
	4SVPA150MAA	4	150	22	19	2570	0.12	300
	2R5SVPA180MAA	2.5	180	20	18	2690	0.12	300
E7	20SVPA47M	20	47	33	29	2630	0.12	188
	16SVPA82MAA	16	82	30	25	2760	0.12	262
	10SVPA150MAA	10	150	30	25	2760	0.12	500
	6SVPA220MAA	6.3	220	22	19	3220	0.12	500
	4SVPA270MAA	4	270	22	19	3220	0.12	500
	2R5SVPA330MAA	2.5	330	20	18	3370	0.12	500
F8	16SVPA180M	16	180	29	28	3430	0.12	576
	10SVPA330M	10	330	24	23	3770	0.12	660
	6SVPA470M	6.3	470	20	19	4130	0.12	592
	4SVPA680M	4	680	20	19	4130	0.12	544
	2R5SVPA820M	2.5	820	19	18	4240	0.12	500

※1 After 2 minutes

※2 The ESR value at 300kHz is a reference one.

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
B6	1.4	7.4	1.6
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9
F8	4.3	13.1	1.9

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVQP Series

Guaranteed at 125°C

This series has advanced characteristics in resistance to heat compared with the SVP series. The SVQP series is best suited for devices that require enhanced reliability.
This product can support lead free-reflow.(※2)



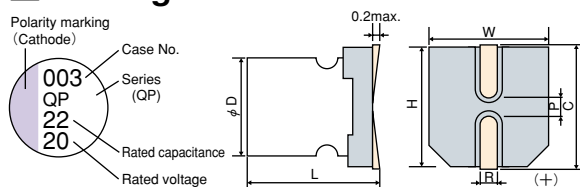
Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +125°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table7		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table7		
ESR	100KHz to 300KHz	Less than or equal to the value of Table7		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+125°C	Z / Z 20°C	0.75 to 1.25
Endurance	125°C, 1,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		ESR	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat ※2	VPS (230°C X 75s)	ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 125°C.

※2 Refer to Page 14 for reflow soldering conditions.

Marking and dimensions



(unit : mm)

Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23)
22						C6
39					C6	
47						E7
56				C6		
82			C6		E7	
100			C6			
120				E7		
150	C6			E7		
220			E7			

※For the minimum packing quantity, please refer to page 57.

■Table7 SVQP Series Characteristics List

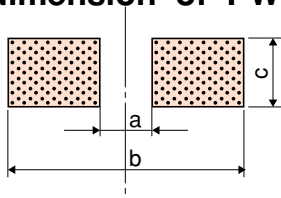
Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current	Allowable ripple current	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
					100kHz (mA) ※2			
					105℃<Tx≤125℃	Tx≤105℃		
C6	20SVQP22M	20	22	60	459	1450	0.10	220
	16SVQP39M	16	39	50	512	1620	0.10	312
	10SVQP56M	10	56	45	538	1700	0.12	280
	6SVQP82M	6.3	82	45	538	1700	0.12	258
	6SVQP100M	6.3	100	40	572	1810	0.12	315
	4SVQP150M	4	150	40	572	1810	0.12	300
E7	20SVQP47M	20	47	45	598	1890	0.12	470
	16SVQP82M	16	82	40	670	2120	0.12	656
	10SVQP120M	10	120	35	810	2560	0.12	600
	10SVQP150M	10	150	35	810	2560	0.12	750
	6SVQP220M	6.3	220	35	810	2560	0.12	693

※1 After 2 minutes

※2 Tx : Ambient temperature

SVQP

■Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SVP Series

Standard SMD type

Standard SMD type product
Use for surface mounted type switching power supplies.
This product can support lead free-reflow.(※2).



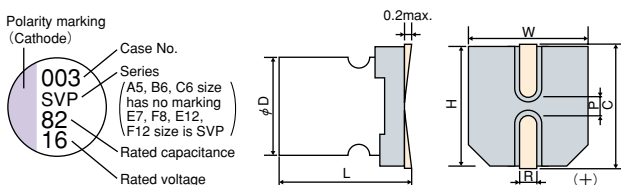
Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M: ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table8		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table8		
ESR	100KHz to 300KHz	Less than or equal to the value of Table8		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
Endurance	105°C, 2,000h, Rated voltage applied (25V→20V applied)	Leakage current	Below an initial standard	
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±10%	
Resistance to soldering heat ※2	VPS (230°C X 75s)	tanδ	1.3 times or less than an initial standard	
		ESR	1.3 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±10%	
		tanδ	1.3 times or less than an initial standard	

※1 In case of some problems for measured values, measure after applying rated voltage for 2.5 to 20V products or 20V for 25V products for 120 minutes at 105°C.

※2 Refer to Page 14 for reflow soldering conditions.

Marking and dimensions



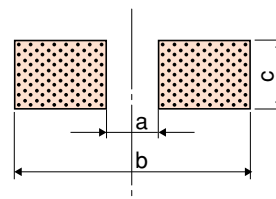
Size Code	φD±0.5	L ^{+0.1} _{-0.4}	W±0.2	H±0.2	C±0.2	R	P±0.2
A5	4.0	5.4	4.3	4.3	5.0	0.6 to 0.8	1.0
B6	5.0	5.9	5.3	5.3	6.0	0.6 to 0.8	1.4
C6	6.3	5.9	6.6	6.6	7.3	0.6 to 0.8	2.1
E7	8.0	6.9	8.3	8.3	9.0	0.6 to 0.8	3.2
F8	10.0	7.9	10.3	10.3	11.0	0.6 to 0.8	4.6
E12	8.0	11.9	8.3	8.3	9.0	0.8 to 1.1	3.2
F12	10.0	12.6	10.3	10.3	11.0	0.8 to 1.1	4.6

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	2.5 (3.3)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23.0)	25 (25.0)
3.3						A5		
4.7					A5			
6.8					A5			C6
10					A5	B6	B6	E7
15					A5	B6	C6	F8
22				A5		B6	C6	F8
27							C6	E12
33			A5		B6		C6	
39			B6			C6		
47				B6	C6		E7	
56					C6	E7	F8	F12
68			B6					
82				C6		E7		
100				C6		F8	E12	
120				C6				
150			C6		E7, F8	F8	F12	
180						F8, E12		
220	C6			E7, F8				
270					F8			
330			E7	F8	F8, E12	F12		
470				F8, E12				
560			E12		F12			
680	E12		F8					
820				F12				
1200			F12					
1500	F12							

Recommended land pattern dimension of PWB



(unit : mm)

Size Code	a	b	c
A5	1.0	6.2	1.6
B6	1.4	7.4	1.6
C6	2.1	9.1	1.6
E7	2.8	11.1	1.9
F8	4.3	13.1	1.9
E12	2.8	11.1	1.9
F12	4.3	13.1	1.9

※For the minimum packing quantity, please refer to page 57.

Table8 SVP Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated Capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current (mA rms)	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
A5	16SVP3R3M	16	3.3	260	660	0.07	26.4
	10SVP4R7M	10	4.7	240	670	0.08	23.5
	10SVP6R8M	10	6.8	240	670	0.09	34.0
	10SVP10M	10	10	220	700	0.10	50.0
	10SVP15M	10	15	200	740	0.10	75.0
	6SVP22M	6.3	22	200	740	0.12	69.3
	4SVP33M	4	33	200	740	0.15	66.0
B6	20SVP10M	20	10	120	1020	0.10	100
	16SVP15M	16	15	120	1020	0.10	120
	16SVP22M	16	22	90	1060	0.10	176
	10SVP33M	10	33	70	1100	0.12	165
	6SVP47M	6.3	47	70	1100	0.12	148
	4SVP39M	4	39	70	1100	0.12	78
	4SVP68M	4	68	60	1400	0.12	136
C6	25SVP6R8M ※2	25	6.8	80	1200	0.10	85
	20SVP22M	20	22	60	1450	0.10	88
	20SVP27M	20	27	60	1450	0.10	108
	16SVP39M	16	39	50	1620	0.10	125
	10SVP47M	10	47	50	1620	0.12	94
	10SVP56M	10	56	45	1700	0.12	112
	6SVP82M	6.3	82	45	1700	0.12	103
	6SVP100M	6.3	100	40	1810	0.12	126
	6SVP120MV	6.3	120	17	2780	0.12	151
	4SVP150MX	4	150	40	1810	0.12	120
E7	2R5SVP220M	2.5	220	23	2390	0.12	110
	25SVP10M ※2	25	10	60	1500	0.10	125
	20SVP33M	20	33	45	1890	0.12	132
	20SVP47M	20	47	45	1890	0.12	188
	16SVP56M	16	56	45	1890	0.12	179
	16SVP82M	16	82	40	2120	0.12	262
	10SVP120M	10	120	35	2560	0.12	240
	10SVP150MX	10	150	35	2560	0.12	300
	6SVP220MX	6.3	220	35	2560	0.12	277
	4SVP330M	4	330	35	2560	0.12	264
F8	25SVP22M	25	22	50	2000	0.10	275
	20SVP56M ※2	20	56	40	2400	0.12	224
	20SVP68M	20	68	40	2400	0.12	272
	16SVP100M	16	100	35	2670	0.12	320
	16SVP150M	16	150	30	3020	0.12	480
	16SVP180MX	16	180	30	3020	0.12	576
	10SVP150M	10	150	30	3020	0.12	300
	10SVP270M	10	270	25	3700	0.12	540
	10SVP330MX	10	330	25	3700	0.12	660
	6SVP220M	6.3	220	25	3700	0.12	277
	6SVP330M	6.3	330	25	3700	0.12	416
	6SVP470MX	6.3	470	25	3700	0.12	592
E12	4SVP680M	4	680	25	3700	0.12	544
	25SVP33M ※2	25	33	30	2980	0.12	413
	20SVP100M	20	100	24	3320	0.15	400
	16SVP180M	16	180	20	3640	0.15	576
	10SVP330M	10	330	17	3950	0.15	660
	6SVP470M	6.3	470	15	4210	0.15	592
	4SVP560M	4	560	13	4520	0.15	448
	2R5SVP680M	2.5	680	13	4520	0.15	340
F12	25SVP56M ※2	25	56	28	3800	0.12	700
	20SVP150M	20	150	20	4320	0.15	600
	16SVP330M	16	330	16	4720	0.15	792
	10SVP560M	10	560	13	5230	0.15	840
	6SVP820M	6.3	820	12	5440	0.15	775
	4SVP1200M	4	1200	12	5440	0.18	960
	2R5SVP1500M	2.5	1500	12	5440	0.18	750

※1 After 2 minutes

※2 The surge voltage of 25V products is 25V. Please consider SVPD series 25V products (whose surge voltage is 29V) in placing a new order.

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SEPC Series

Super low ESR

Miniaturization and Low profile

Large capacitance

This is an even lower ESR series based on our SEP series.
Suitable for use with motherboards, servers, VGA, etc.
Lead free-flow is supported.

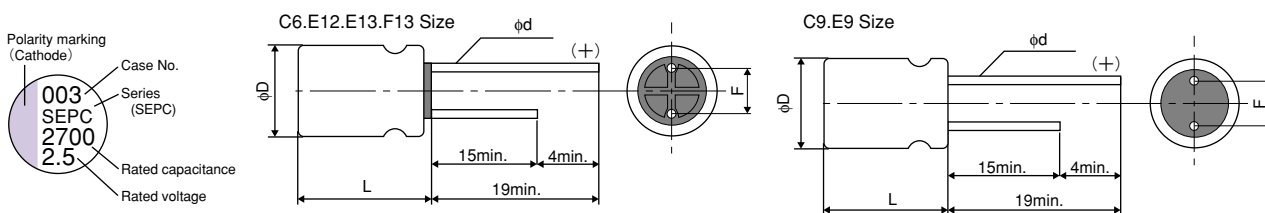


Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table9		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table9		
ESR	100KHz to 300KHz	Less than or equal to the value of Table9		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90% RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
		ESR	Below an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 105°C.

Marking and dimensions



C9, E9 size flat rubber is used.

Size List

		RV : Rated voltage (SV) : Surge voltage (Room temperature)			
μF	RV (SV)	2.5 (3.3)	4.0 (5.2)	6.3 (8.2)	16.0 (18.4)
100					C6, C9
180					E9, E12
270					E12
470				E9, E13	F13
560	C9, E9		E9, E13	E9	
680			E13	F13	
820	E9, E13		F13		
1000	E9				
1500				F13	
2700	F13				

(unit : mm)				
Size Code	φD±0.5	Lmax.	F	φd±0.05
C6	6.3	6.0	2.5±0.5	0.45
C9	6.3	9.0	2.5±0.5	0.6
E9	8.0	9.0	3.5±0.5	0.6
E12	8.0	12.0	3.5±0.5	0.6
E13	8.0	13.0	3.5±0.5	0.6
F13	10.0	13.0	5.0±0.5	0.6

※For the minimum packing quantity, please refer to page 55.

■Table9 SEPC Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current 100kHz (mA _{rms}) at 105°C	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
C6	16SEPC100M	16	100	24	2400	0.10	320
C9	16SEPC100MW	16	100	10	4500	0.10	500
	2SEPC560MW	2.5	560	7	5600	0.10	500
E9	16SEPC180MX	16	180	10	5000	0.10	576
	6SEPC470MX	6.3	470	8	5700	0.10	592
	6SEPC560MX	6.3	560	7	6100	0.10	705
	4SEPC560MX	4	560	7	6100	0.10	500
	2SEPC560MX	2.5	560	8	4700	0.10	280
	2SEPC820MX	2.5	820	7	6100	0.10	500
	2SEPC820MY	2.5	820	5	7200	0.10	500
	2SEPC1000MX	2.5	1000	7	6100	0.10	500
E12	16SEPC180M	16	180	16	4360	0.10	576
	16SEPC270M	16	270	11	5000	0.10	864
E13	6SEPC470M	6.3	470	8	5700	0.10	592
	4SEPC560M	4	560	7	6100	0.10	500
	4SEPC680M	4	680	7	6100	0.10	544
	2R5SEPC820M	2.5	820	7	6100	0.10	500
F13	16SEPC470M	16	470	10	6100	0.10	1504
	6SEPC680M	6.3	680	7	6640	0.10	857
	6SEPC1500M	6.3	1500	10	5560	0.10	1890
	4SEPC820M	4	820	7	6640	0.10	656
	2SEPC2700M	2.5	2700	10	5560	0.10	1350

※1 After 2 minutes

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SEQP Series

125°C guaranteed

32V product

This series has advanced characteristics in resistance to heat compared with the SEP series, and adds a rated voltage of 32V. Suitable for use in increasing device reliability, 32V products may be used on 16 to 24V line industrial devices. Lead free-flow is supported.

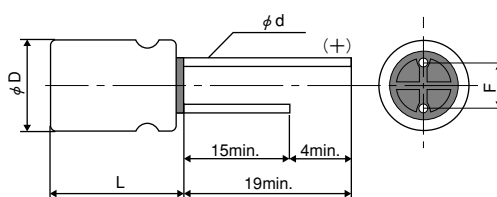
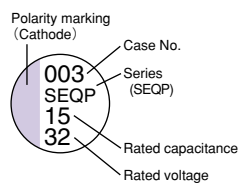


Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +125°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table10		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table10		
ESR	100KHz to 300KHz	Less than or equal to the value of Table10		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+125°C	Z / Z 20°C	0.75 to 1.25
Endurance	125°C, 1,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		ESR	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95% RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
		ESR	Below an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 120 minutes at 125°C.

Marking and dimensions



(unit : mm)

Size Code	φD±0.5	Lmax.	F	φd±0.05
C6	6.3	6.0	2.5±0.5	0.45
E7	8.0	7.0	3.5±0.5	0.45
F8	10.0	8.0	5.0±0.5	0.50
E12	8.0	12.0	3.5±0.5	0.60
F13	10.0	13.0	5.0±0.5	0.60

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	4.0 (5.2)	6.3 (8.4)	10 (12)	16 (18.4)	20 (23)	32 (37)
6.8							E7
15							F8
18							E12
22						C6	
39					C6		
47						E7	
56				C6			
68						F8	
82			C6		E7		
100						E12	
120				E7			
150	C6		E7		F8	F13	
180					E12		
270				F8			
330	E7		F8	E12	F13		
470			E12				
560	E12			F13			
680	F8						
820			F13				
1200	F13						

※For the minimum packing quantity, please refer to page 55.

■Table10 SEQP Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current	Allowable ripple current	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
					100kHz (mA) ※2			
					105°C<Tx≤125°C	Tx≤105°C		
C6	20SEQP22M	20	22	60	458	1450	0.10	220
	16SEQP39M	16	39	50	512	1620	0.10	312
	10SEQP56M	10	56	45	537	1700	0.12	280
	6SEQP82M	6.3	82	45	537	1700	0.12	258
	4SEQP150M	4	150	40	572	1810	0.12	300
E7	32SEQP6R8M	32	6.8	100	440	1400	0.10	44
	20SEQP47M	20	47	45	598	1890	0.12	470
	16SEQP82M	16	82	40	670	2120	0.12	656
	10SEQP120M	10	120	35	810	2560	0.12	600
	6SEQP150M	6.3	150	35	810	2560	0.12	472
	4SEQP330M	4	330	35	810	2560	0.12	660
F8	32SEQP15M	32	15	80	560	1800	0.10	96
	20SEQP68M	20	68	40	759	2400	0.12	272
	16SEQP150M	16	150	30	955	3020	0.12	480
	10SEQP270M	10	270	25	1170	3700	0.12	540
	6SEQP330M	6.3	330	25	1170	3700	0.12	416
	4SEQP680M	4	680	25	1170	3700	0.12	544
E12	32SEQP18M	32	18	50	790	2500	0.12	115
	20SEQP100M	20	100	24	1050	3320	0.15	400
	16SEQP180M	16	180	20	1151	3640	0.15	576
	10SEQP330M	10	330	17	1250	3950	0.15	660
	6SEQP470M	6.3	470	15	1332	4210	0.15	592
	4SEQP560M	4	560	13	1430	4520	0.15	448
F13	20SEQP150M	20	150	20	1367	4320	0.15	600
	16SEQP330M	16	330	16	1493	4720	0.15	792
	10SEQP560M	10	560	13	1655	5230	0.15	840
	6SEQP820M	6.3	820	12	1721	5440	0.15	775
	4SEQP1200M	4	1200	12	1721	5440	0.18	960

※1 After 2 minutes

※2 Tx : Ambient temperature

Frequency coefficient for ripple current

Frequency	120Hz≤ f < 1kHz	1kHz≤ f < 10kHz	10kHz≤ f < 100kHz	100kHz≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SEP Series

Standard radial lead type

Guaranteed at 105°C for 3,000h

This is a radial lead type using conductive polymer based on the SVP series.

Lead free-flow is supported.



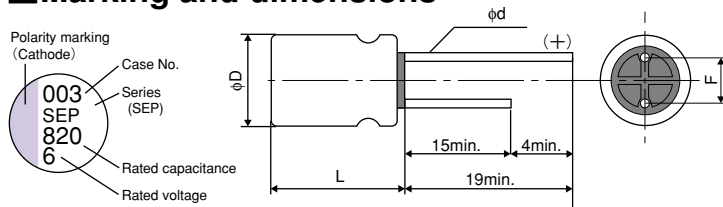
Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table11		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table11		
ESR	100KHz to 300KHz	Less than or equal to the value of Table11		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
Endurance	105°C, 3,000h, Rated voltage applied (2.5V→2,000h), (25V→20V applied)	ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	ESR	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ESR	Below an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±5%	
		tanδ	Below an initial standard	

※1 In case of some problems for measured values, measure after applying rated voltage for 2.5 to 20V products or temperature derating voltage for 25V products for 120 minutes at 105°C.

Marking and dimensions

(unit : mm)



Size Code	φD±0.5	Lmax.	F	φd±0.05
C6	6.3	6.0	2.5±0.5	0.45
E7	8.0	7.0	3.5±0.5	0.45
F8	10.0	8.0	5.0±0.5	0.50
E12	8.0	12.0	3.5±0.5	0.60
F13	10.0	13.0	5.0±0.5	0.60

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	2.5 (3.3)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23.0)	25 (25.0)
6.8								C6
10								E7
22							C6	F8
33							E7	E12
39						C6		
47							E7	
56					C6		F8	F13
68							F8	
82				C6		E7		
100		C6					F8,E12	
120					E7			
150		C6	E7			F8	F13	
180						E12		
220			E7					
270					F8			
330			E7	F8	E12	F13		
470			F8	E12				
560			E12		F13			
680	E12		F8					
820				F13				
1200			F13					
1500	F13							

※For the minimum packing quantity, please refer to page 55.

■Table11 SEP Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Rated ripple current 100kHz (mA rms) at 105°C	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
C6	25SEP6R8M ※2	25	6.8	80	1200	0.10	170
	20SEP22M	20	22	60	1450	0.10	220
	16SEP39M	16	39	50	1620	0.10	312
	10SEP56M	10	56	45	1700	0.12	280
	6SEP82M	6.3	82	45	1700	0.12	258
	4SEP100M	4	100	40	1810	0.12	200
	4SEP150M	4	150	40	1810	0.12	300
E7	25SEP10M ※2	25	10	60	1500	0.10	250
	20SEP33M	20	33	45	1890	0.12	330
	20SEP47M	20	47	45	1890	0.12	470
	16SEP82M	16	82	40	2120	0.12	656
	10SEP120M	10	120	35	2560	0.12	600
	6SEP150M	6.3	150	35	2560	0.12	472
	4SEP220M	4	220	35	2560	0.12	440
	4SEP330M	4	330	35	2560	0.12	660
F8	25SEP22M ※2	25	22	50	2000	0.10	275
	20SEP56M	20	56	40	2400	0.12	224
	20SEP68M	20	68	40	2400	0.12	272
	20SEP100MX	20	100	35	2570	0.12	400
	16SEP150M	16	150	30	3020	0.12	480
	10SEP270M	10	270	25	3700	0.12	540
	6SEP330M	6.3	330	25	3700	0.12	416
	4SEP470M	4	470	25	3700	0.12	376
	4SEP680M	4	680	25	3700	0.12	544
E12	25SEP33M ※2	25	33	30	2980	0.12	413
	20SEP100M	20	100	24	3320	0.15	400
	16SEP180M	16	180	20	3640	0.15	576
	10SEP330M	10	330	17	3950	0.15	660
	6SEP470M	6.3	470	15	4210	0.15	592
	4SEP560M	4	560	13	4520	0.15	448
	2R5SEP680M	2.5	680	13	4520	0.15	340
F13	25SEP56M ※2	25	56	28	3800	0.12	700
	20SEP150M	20	150	20	4320	0.15	600
	16SEP330M	16	330	16	4720	0.15	792
	10SEP560M	10	560	13	5230	0.15	840
	6SEP820M	6.3	820	12	5440	0.15	775
	4SEP1200M	4	1200	12	5440	0.18	960
	2R5SEP1500M	2.5	1500	12	5440	0.18	750

※1 After 2 minutes

※2 The surge voltage of 25V products is 25V. Please consider SVPD series 25V products (whose surge voltage is 29V) in placing a new order.

Frequency coefficient for ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.3	0.7	1

SF Series

Radial lead type.5mm height (max.)

The SF series is low-profile, having a maximum height of 5mm. Use this series for smooth power supply of notebook PCs.

Lead free-flow is supported.

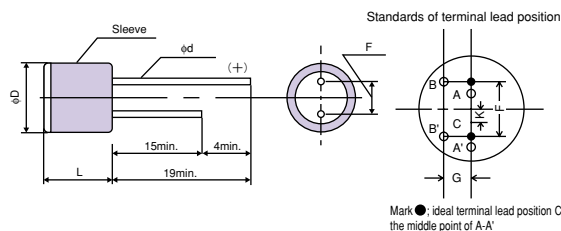


Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table12		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table12		
ESR	100KHz to 300KHz	Less than or equal to the value of Table12		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±20%	
Damp heat (Steady state)	60°C, 90 to 95% RH, No-applied voltage 500h,	tanδ	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±5%	
		tanδ	1.5 times or less than an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±5%	

※1 In case of some problems for measured values, measure after applying rated voltage for 30 minutes at 105°C.

Dimensions



(unit : mm)

Size Code	φD+0.5max.	Lmax.	F	φd±0.05
E1	8.0	5.0	3.5±0.5	0.6

Size List

RV : Rated voltage

(SV) : Surge voltage (Room temperature)

μF	RV (SV)	4.0 (5.2)	6.3 (8.2)
150			E1
220		E1	

※For the minimum packing quantity, please refer to page 55.

■Table12 SF Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA _{rms})※2	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
E1	6SF150M	6.3	150	32	2420	0.07	189
	4SF220M	4	220	30	2510	0.07	176

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

SP Series

Large Capacitance

Optimum for Audio etc

Low ESR

The characteristics of SP series are large capacitance (about 2 times of previous value) and low ESR (about half of previous value). It is optimum to use around MPU of computer equipment. Also, suitable for audio because OFC is used as the lead wires. Lead free-flow is supported.



Specifications

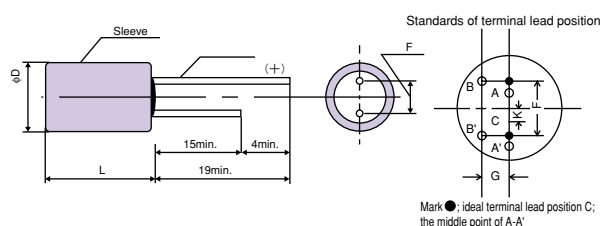
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table13		
Leakage current ※2	After 2 minutes	Less than or equal to the value of Table13		
ESR	100KHz to 300KHz	Less than or equal to the value of Table13		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z _{20°C}	0.75 to 1.25
		+105°C	Z / Z _{20°C}	0.75 to 1.25
Endurance ※3	105°C, 1,000 to 2,000h Rated voltage applied (25V→20V applied) ※1	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ΔC/C	Within ±5%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 Please reduce 0.25V per 1°C from over 85°C for 25V products.

※2 In case of some problems for measured values, measure after applying rated voltage for 2 to 20V products or temperature derating voltage for 25V products for 30 minutes at 105°C.

※3 C', E', F', C, D size : 1,000h. E, F, Fo, G size : 2,000h. (2V, 25V, 4SP1000M, 2R5SP1200M : 1,000h)

Dimensions



(unit : mm)

Size Code	φD±0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
C'	6.3	6.0	2.5±0.5	0.60	0.5	0.5
E'	8.0	6.0	3.5±0.5	0.60	0.8	0.8
F'	10.0	6.0	5.0±0.5	0.60	0.8	0.8
C	6.3	7.8	2.5±0.5	0.60	0.5	0.5
D	6.3	10.8	2.5±0.5	0.60	0.5	0.5
E	8.0	11.5	3.5±0.5	0.60	0.8	0.8
F	10.0	11.5	5.0±0.5	0.60	0.8	0.8
Fo	10.0	21.0	5.0±0.5	0.80	0.8	0.8
G	12.5	23.0	5.0±1.0	0.80	0.8	0.8

Size List

RV : Rated voltage (SV) : Surge voltage (Room temperature)

μF	RV (SV)	2 (2.6)	2.5 (3.3)	4 (5.2)	6.3 (8.2)	10 (12)	16 (18.4)	20 (23.0)	25 (25.0)
6.8									C'
10									C
18									D
22									
33								C'	E
47							C	E'	
56						C'			F
68					C'		E'	F',D	
82						C			
100				C'		E'	F',D		
120					C			E	
150				C	E'	D			
180						F'	E	F	
220				E'	F',D				
270						E	F		
330				F'					
390					E				
470						F			
560				E					
680					F				
820				F					
1000	F			F					
1200		F							
1500				Fo					
1800	Fo								
2200				G					

※For the minimum packing quantity, please refer to page 55.

Table13 SP Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA _{rms}) ※2	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
C'	25SP6R8M	25	6.8	60	1510	0.06	17.00
	20SP22M	20	22	50	1580	0.06	44.00
	16SP33M	16	33	50	1580	0.06	52.80
	10SP56M	10	56	45	1710	0.06	56.00
	6SP68M	6.3	68	40	1850	0.06	42.84
	4SP100M	4	100	40	1850	0.06	40.00
E'	20SP47M	20	47	36	2210	0.07	94.00
	16SP68M	16	68	34	2280	0.07	108.80
	10SP100M	10	100	32	2350	0.07	100.00
	6SP150M	6.3	150	30	2420	0.07	94.50
	4SP220M	4	220	28	2510	0.07	88.00
F'	20SP68M	20	68	34	2800	0.07	136.00
	16SP100M	16	100	32	2890	0.07	160.00
	10SP180M	10	180	29	2990	0.07	180.00
	6SP220M	6.3	220	28	3100	0.07	138.60
	4SP330M	4	330	24	3230	0.07	132.00
C	25SP10M	25	10	55	1560	0.07	25.00
	20SP33M	20	33	45	1710	0.07	66.00
	16SP47M	16	47	45	1710	0.07	75.20
	10SP82M	10	82	40	1850	0.07	82.00
	6SP120M	6.3	120	35	1930	0.07	75.60
	4SP150M	4	150	35	1930	0.07	60.00
D ※3	25SPS18M	25	18	40	2230	0.08	45.00
	20SPS68M	20	68	30	2580	0.08	136.00
	16SPS100M	16	100	25	2820	0.08	160.00
	10SPS150M	10	150	25	2820	0.08	150.00
	6SPS220M	6.3	220	20	3160	0.08	138.60
	4SPS270M	4	270	20	3160	0.08	108.00
E	25SP33M	25	33	30	2780	0.08	82.50
	20SP120M	20	120	24	3110	0.08	240.00
	16SP180M	16	180	20	3410	0.08	288.00
	10SP270M	10	270	18	3600	0.08	270.00
	6SP390M	6.3	390	16	3810	0.08	245.70
	4SP560M	4	560	14	4080	0.08	224.00
F	25SP56M	25	56	25	3260	0.08	140.00
	20SP180M	20	180	20	4280	0.08	360.00
	16SP270M	16	270	18	4400	0.08	432.00
	10SP470M	10	470	15	4510	0.08	470.00
	6SP680M	6.3	680	13	4840	0.08	428.40
	4SP820M	4	820	12	5040	0.08	328.00
	4SP1000M	4	1000	12	5040	0.08	400.00
	2R5SP1200M	2.5	1200	12	5040	0.08	450.00
Fo	2SP1000M	2	1000	11	5260	0.08	400.00
	4SP1500M	4	1500	8	6500	0.10	600.00
G	2SP1800M	2	1800	8	6500	0.10	720.00
	4SP2200M	4	2200	9	7100	0.12	880.00

※1 After 2 minutes ※2 100kHz, +45°C

※3 D size is indicated to SPS series.

Temperature coefficient for allowable ripple current

Ambient Temp.	Tx ≤ 45°C	45°C < Tx ≤ 65°C	65°C < Tx ≤ 85°C	85°C < Tx ≤ 95°C	95°C < Tx ≤ 105°C
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	120Hz ≤ f < 1kHz	1kHz ≤ f < 10kHz	10kHz ≤ f < 100kHz	100kHz ≤ f ≤ 500kHz
Coefficient	0.05	0.2	0.5	1

SC Series

Standard radial lead type

Suitable for noise limiters and switching power supplies that make a point of high frequency characteristics. Also, make use of it when needed long life span and high reliability. Lead free-flow is supported.



Specifications

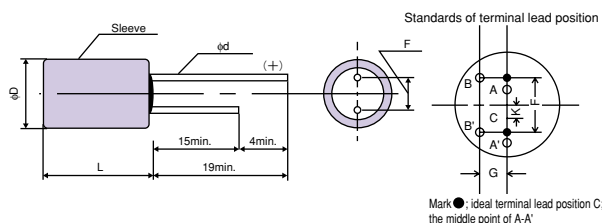
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table14		
Leakage current ※2	After 2 minutes	Less than or equal to the value of Table14		
ESR	100KHz to 300KHz	Less than or equal to the value of Table14		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied (25V→20V applied) ※1	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±10%	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	Leakage current	Below an initial standard (after voltage processing)	
		ΔC/C	Within ±5%	

※1 Please reduce 0.25V per 1°C from over 85°C for 25V products.

※2 In case of some problems for measured values, measure after applying rated voltage for 6.3 to 16 and 30V products or temperature derating voltage for 25V products for 30 minutes at 105°C.

Dimensions

(unit : mm)



Size Code	φD±0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
A	4.0	7.8	2.0±0.5	0.45	0.5	0.5
B	5.0	7.8	2.0±0.5	0.45	0.5	0.5
C	6.3	7.8	2.5±0.5	0.45	0.5	0.5
D	6.3	10.8	2.5±0.5	0.60	0.5	0.5
E	8.0	11.5	3.5±0.5	0.60	0.8	0.8
F	10.0	11.5	5.0±0.5	0.60	0.8	0.8

Size List

RV : Rated voltage
(SV) : Surge voltage (Room temperature)

μF	RV (SV)	6.3 (7.2)	10 (12)	16 (18.4)	25 (25.0)	30 (34.5)
1.0					A	A
1.5					A	B
2.2				A	B	B
3.3				A	B	C
4.7			A	B	C	D
6.8	A		B	C	D	D
10		B		C	E	E
15	B		C	D	F	F
22		C	D	E	F	F
33	C		D	E	F	F
47		D	E	F	F	F

※For the minimum packing quantity, please refer to page 55.

■Table14 SC Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA rms) ※2	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
A	30SC1M	30	1.0	350	430	0.03	1.00
	25SC1M	25	1.0	350	430	0.03	0.50
	25SC1R5M	25	1.5	300	435	0.03	0.50
	16SC2R2M	16	2.2	280	450	0.04	0.50
	16SC3R3M	16	3.3	280	500	0.04	0.53
	10SC4R7M	10	4.7	280	540	0.05	0.50
	6SC6R8M	6.3	6.8	250	560	0.05	0.50
B	30SC1R5M	30	1.5	300	435	0.03	1.00
	30SC2R2M	30	2.2	250	695	0.03	1.32
	25SC2R2M	25	2.2	200	695	0.03	0.55
	25SC3R3M	25	3.3	200	700	0.03	0.83
	16SC4R7M	16	4.7	180	720	0.04	0.75
	16SC6R8M	16	6.8	150	745	0.04	1.09
	10SC10M	10	10	150	780	0.05	1.00
	6SC15M	6.3	15	120	815	0.05	0.95
C	30SC3R3M	30	3.3	200	820	0.03	1.98
	25SC4R7M	25	4.7	100	1130	0.03	1.18
	25SC6R8M	25	6.8	100	1140	0.03	1.70
	25SC10M	25	10	90	1150	0.03	2.50
	16SC15M	16	15	90	1230	0.04	2.40
	10SC22M	10	22	70	1270	0.05	2.20
	6SC33M	6.3	33	70	1320	0.05	2.08
D	30SC4R7M	30	4.7	120	1300	0.04	2.82
	30SC6R8M	30	6.8	120	1340	0.04	4.08
	25SC15M	25	15	70	1650	0.04	3.75
	16SC22M	16	22	70	1800	0.05	3.52
	16SC33M	16	33	70	1900	0.06	5.28
	10SC47M	10	47	60	2020	0.06	4.70
E	30SC10M	30	10	110	1380	0.06	6.00
	25SC22M	25	22	40	2330	0.06	5.50
F	30SC22M	30	22	80	1830	0.06	13.20
	25SC33M	25	33	35	2900	0.06	8.25
	25SC47M	25	47	35	2980	0.06	11.75

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

SA Series

Large capacitance

Miniaturization

SA series is miniaturized SC series with large capacitance. Suitable for high frequency switching power supplies, etc. Lead free-flow is supported.



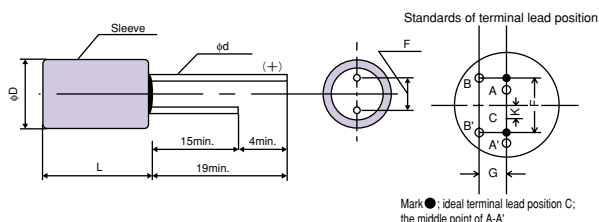
Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table15		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table15		
ESR	100KHz to 300KHz	Less than or equal to the value of Table15		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
		ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
Endurance	105°C, 2,000h, Rated voltage applied	Leakage current	Below an initial standard	
		ΔC/C	Within ±10%	
		tanδ	1.5 times or less than an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	Leakage current	Below an initial standard	
		ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 30 minutes at 105°C.

Dimensions

(unit : mm)



Size Code	φD+0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
C	6.3	7.8	2.5±0.5	0.45	0.5	0.5
D	6.3	10.8	2.5±0.5	0.60	0.5	0.5
E	8.0	11.5	3.5±0.5	0.60	0.8	0.8
F	10.0	11.5	5.0±0.5	0.60	0.8	0.8
G	12.5	23.0	5.0±1.0	0.80	0.8	0.8
H	16.0	26.0	7.5±1.0	0.80	0.8	0.8

Size List

RV : Rated voltage
(SV) : Surge voltage (Room temperature)

μF	RV (SV)	6.3 (7.2)	10 (12)	16 (18.4)	20 (23.0)
15					C
22					C
33				C	D
47	C			D	E
68			D		E
100				E	F
150	E			F	
220			F		
330	F				
470				G	
1000				H	
2200	H				

※For the minimum packing quantity, please refer to page 55.

■Table15 SA Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA _{rms}) ※2	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
C	20SA15M	20	15	90	1200	0.06	6.00
	20SA22M	20	22	70	1300	0.06	8.80
	16SA33M	16	33	70	1370	0.06	10.56
	6SA47M	6.3	47	60	1430	0.07	5.92
D	20SA33M	20	33	70	1710	0.06	13.20
	16SA47M	16	47	60	1830	0.06	15.04
	10SA68M	10	68	50	2000	0.07	13.60
E	20SA47M	20	47	40	2450	0.06	18.80
	20SA68M	20	68	36	2600	0.06	27.20
	16SA100M	16	100	30	2740	0.06	32.00
	6SA150M	6.3	150	30	2780	0.07	18.90
F	20SA100M	20	100	30	3210	0.06	40.00
	16SA150M	16	150	28	3260	0.06	48.00
	10SA220M	10	220	27	3370	0.07	44.00
	6SA330M	6.3	330	25	3500	0.07	41.58
G	16SA470M	16	470	20	6080	0.08	300.80
H	16SA1000M	16	1000	15	9750	0.09	640.00
	6SA2200M	6.3	2200	15	9750	0.13	554.40

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

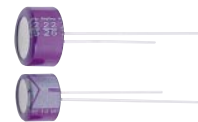
Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

SL Series

Low-profile products

The SL series is low profile with a category upper limit temperature of 105°C. Use the SL series for compact and slim designs, such as VTRs, video cameras, car stereos, etc. Lead free-flow is supported.



Specifications

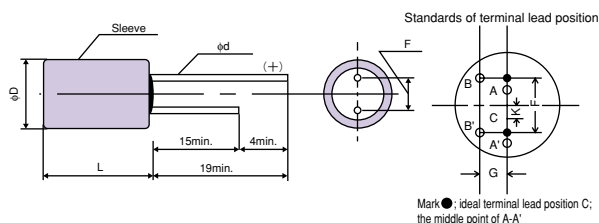
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table16		
Leakage current ※2	After 2 minutes	Less than or equal to the value of Table16		
ESR	100KHz to 300KHz	Less than or equal to the value of Table16		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 2,000h, Rated voltage applied (E', F' size ; 1,000h) (25V→20V applied) ※1	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH, 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ΔC/C	Within ±5%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 Please reduce 0.25V per 1°C from over 85°C for 25V products.

※2 In case of some problems for measured values, measure after applying rated voltage for 4 to 16V products or temperature derating voltage for 25V products for 30 minutes at 105°C.

Dimensions

(unit : mm)



Size Code	φD±0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
A'	4.0	6.0	1.5±0.5	0.45	0.5	0.5
B'	5.0	6.0	2.0±0.5	0.45	0.5	0.5
C'	6.3	6.0	2.5±0.5	0.45	0.5	0.5
E'	8.0	6.0	3.5±0.5	0.50	0.8	0.8
F'	10.0	6.0	5.0±0.5	0.50	0.8	0.8

Size List

RV : Rated voltage

(SV) : Surge voltage (Room temperature)

μF	RV (SV)	4 (4.6)	6.3 (7.2)	10 (12)	16 (18.4)	25 (25.0)
1.0						A'
1.5						A'
2.2					A'	B'
3.3					A'	B'
4.7				A'	B'	C'
6.8			A'		B'	C'
10				B'	C'	
15			B'		C'	E'
22				C'		F'
33				C'		
47				C'	E'	
68				E'	F'	
100			E'	F'		
150		E'	F'			
220		F'				

※For the minimum packing quantity, please refer to page 55.

■Table16 SL Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA rms) ※2	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
A'	25SL1M	25	1	450	430	0.05	0.50
	25SL1R5M	25	1.5	400	435	0.05	0.75
	16SL2R2M	16	2.2	400	450	0.05	0.70
	16SL3R3M	16	3.3	400	500	0.06	1.06
	10SL4R7M	10	4.7	400	540	0.06	0.94
	6SL6R8M	6.3	6.8	350	560	0.06	0.86
B'	25SL2R2M	25	2.2	250	695	0.05	1.10
	25SL3R3M	25	3.3	250	700	0.05	1.65
	16SL4R7M	16	4.7	250	720	0.05	1.50
	16SL6R8M	16	6.8	180	745	0.05	2.18
	10SL10M	10	10	150	780	0.05	2.00
	6SL15M	6.3	15	120	815	0.06	1.89
C'	25SL4R7M	25	4.7	100	1130	0.06	2.35
	25SL6R8M	25	6.8	100	1140	0.06	3.40
	16SL10M	16	10	100	1150	0.06	3.20
	16SL15M	16	15	100	1230	0.06	4.80
	10SL22M	10	22	80	1270	0.06	4.40
	10SL33M	10	33	80	1350	0.06	6.60
	10SL47M	10	47	70	1430	0.06	9.40
E'	25SL15M	25	15	75	1400	0.07	7.50
	16SL47M	16	47	70	1550	0.07	15.04
	10SL68M	10	68	65	1600	0.07	13.60
	6SL100M	6.3	100	65	1600	0.07	12.60
	4SL150M	4	150	60	2000	0.07	12.00
F'	25SL22M	25	22	70	1600	0.07	11.00
	16SL68M	16	68	65	1850	0.07	21.76
	10SL100M	10	100	60	2100	0.07	20.00
	6SL150M	6.3	150	60	2100	0.07	18.90
	4SL220M	4	220	55	2400	0.07	17.60

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

SH Series

Long Life (105°C X 5,000h)

SH series has a long life (guaranteed at 105°C for 5,000h) with keeping high frequency characteristics.

Please use the SH series for industrial equipment that requires high reliability. Lead free-flow is supported.



Specifications

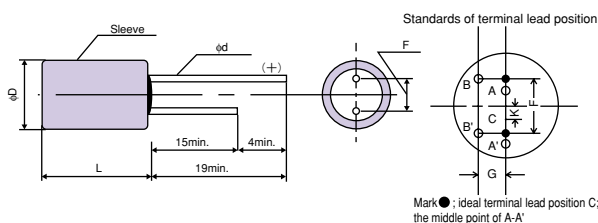
Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table17		
Leakage current ※2	After 2 minutes	Less than or equal to the value of Table17		
ESR	100KHz to 300KHz	Less than or equal to the value of Table17		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 5,000h, Rated voltage applied (25V→20V applied) ※1	ΔC/C	Within ±30%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	5 times or less than an initial standard	
		ΔC/C	Within ±10%	
Damp heat (Steady state)	60°C, 90 to 95%RH 1,000h, No-applied voltage	tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
		ΔC/C	Within ±5%	
		tanδ	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	Leakage current	Below an initial standard (after voltage processing)	

※1 Please reduce 0.25V per 1°C from over 85°C for 25V products.

※2 In case of some problems for measured values, measure after applying rated voltage for 6.3 to 20V products or temperature derating voltage for 25V products for 30 minutes at 105°C.

Dimensions

(unit : mm)



Size Code	φD±0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
A	4.0	7.8	2.0±0.5	0.45	0.5	0.5
B	5.0	7.8	2.0±0.5	0.45	0.5	0.5
C	6.3	7.8	2.5±0.5	0.45	0.5	0.5
D	6.3	10.8	2.5±0.5	0.60	0.5	0.5
E	8.0	11.5	3.5±0.5	0.60	0.8	0.8
F	10.0	11.5	5.0±0.5	0.60	0.8	0.8

Size List

RV : Rated voltage

(SV) : Surge voltage (Room temperature)

μF	RV (SV)	6.3 (7.2)	10 (12)	16 (18.4)	20 (23.0)	25 (25.0)
1.0						A
1.5						A
2.2				A		B
3.3				A		B
4.7			A	B		C
6.8	A		B			C
10			B			C
15	B				C	D
22					C	
33				C	D	
47	C			D	E	
68			D		E	
100				E	F	
150	E			F		
220			F			
330	F					

※For the minimum packing quantity, please refer to page 55.

■Table17 SH Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA _{rms})※2	Tangent of loss angle (max.)	Leakage current (μA) (max.)※1
A	25SH1M	25	1.0	350	430	0.03	0.50
	25SH1R5M	25	1.5	300	435	0.03	0.75
	16SH2R2M	16	2.2	280	450	0.04	0.70
	16SH3R3M	16	3.3	280	500	0.04	1.06
	10SH4R7M	10	4.7	280	540	0.05	0.94
	6SH6R8M	6.3	6.8	250	560	0.05	0.86
B	25SH2R2M	25	2.2	200	695	0.03	1.10
	25SH3R3M	25	3.3	200	700	0.03	1.65
	16SH4R7M	16	4.7	180	720	0.04	1.50
	16SH6R8M	16	6.8	150	745	0.04	2.18
	10SH10M	10	10	150	780	0.05	2.00
	6SH15M	6.3	15	120	815	0.05	1.89
C	25SH4R7M	25	4.7	100	1130	0.03	2.35
	25SH6R8M	25	6.8	100	1140	0.03	3.40
	25SH10M	25	10	90	1150	0.03	5.00
	20SH15M	20	15	90	1200	0.05	6.00
	20SH22M	20	22	70	1300	0.05	8.80
	16SH33M	16	33	70	1370	0.06	10.56
	6SH47M	6.3	47	60	1430	0.07	5.92
D	25SH15M	25	15	70	1650	0.04	7.50
	20SH33M	20	33	70	1710	0.06	13.20
	16SH47M	16	47	60	1830	0.06	15.04
	10SH68M	10	68	50	2000	0.07	13.60
E	20SH47M	20	47	40	2450	0.06	18.80
	20SH68M	20	68	36	2600	0.06	27.20
	16SH100M	16	100	30	2740	0.06	32.00
	6SH150M	6.3	150	30	2780	0.07	18.90
F	20SH100M	20	100	30	3210	0.06	40.00
	16SH150M	16	150	28	3260	0.06	48.00
	10SH220M	10	220	27	3370	0.07	44.00
	6SH330M	6.3	330	25	3500	0.07	41.58

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

SS Series

Miniaturization of SC, SA and SL series

SS series is a miniaturized version of SC, SA and SL series. Suitable for switching power supplies, etc. to make more compact. Lead free-flow is supported.



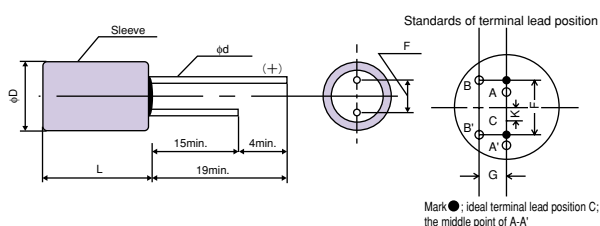
Specifications

Items	Conditions	Characteristics		
Category temperature range	—	-55°C to +105°C		
Tolerance on rated capacitance	120Hz	M : ±20%		
Tangent of loss angle	120Hz	Less than or equal to the value of Table18		
Leakage current ※1	After 2 minutes	Less than or equal to the value of Table18		
ESR	100KHz to 300KHz	Less than or equal to the value of Table18		
Characteristics of impedance ratio at high temp. and low temp.	Based the value at 100KHz, +20°C	-55°C	Z / Z 20°C	0.75 to 1.25
		+105°C	Z / Z 20°C	0.75 to 1.25
Endurance	105°C, 1,000h, Rated voltage applied (E, F size : 2,000h)	ΔC/C	Within ±20%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard	
Damp heat (Steady state)	60°C, 90 to 95%RH 1,000h, No-applied voltage	ΔC/C	Within ±20%	
		tanδ	2 times or less than an initial standard	
		Leakage current	Below an initial standard	
Resistance to soldering heat	Flow method (260±5°C X 10s)	ΔC/C	Within ±5%	
		tanδ	1.5 times or less than an initial standard	
		Leakage current	Below an initial standard (after voltage processing)	

※1 In case of some problems for measured values, measure after applying rated voltage for 30 minutes at 105°C.

Dimensions

(unit : mm)



Size Code	φD±0.5max.	Lmax.	F	φd±0.05	Gmax.	Kmax.
A'	4.0	6.0	1.5±0.5	0.45	0.5	0.5
B'	5.0	6.0	2.0±0.5	0.45	0.5	0.5
C'	6.3	6.0	2.5±0.5	0.45	0.5	0.5
D	6.3	10.8	2.5±0.5	0.60	0.5	0.5
E	8.0	11.5	3.5±0.5	0.60	0.8	0.8
F	10.0	11.5	5.0±0.5	0.60	0.8	0.8

Size List

RV : Rated voltage
(SV) : Surge voltage (Room temperature)

μF	RV (SV)	4 (4.6)	6.3 (7.2)	10 (12)	16 (18.4)	20 (23.0)
2.2						A'
3.3						A'
4.7					A'	B'
6.8					A'	B'
10				A'	B'	C'
15			A'		B'	C'
22				B'		C'
33			B'		C'	
47						D
68	C'				D	
100				D		E
150	D			E		F
220			E			
330				F		
470	F					

※For the minimum packing quantity, please refer to page 55.

Table18 SS Series Characteristics List

Size Code	Part Number	Rated voltage (V)	Rated capacitance (μF)	ESR 100kHz to 300kHz (mΩ) (max.)	Allowable ripple current (mA rms) ※2	Tangent of loss angle (max.)	Leakage current (μA) (max.) ※1
A'	20SS2R2M	20	2.2	400	450	0.05	2.20
	20SS3R3M	20	3.3	400	500	0.06	3.30
	16SS4R7M	16	4.7	400	540	0.06	3.76
	16SS6R8M	16	6.8	400	540	0.06	5.44
	10SS10M	10	10	350	560	0.06	5.00
	6SS15M	6.3	15	350	560	0.06	4.73
B'	20SS4R7M	20	4.7	250	720	0.05	4.70
	20SS6R8M	20	6.8	180	745	0.05	6.80
	16SS10M	16	10	150	780	0.05	8.00
	16SS15M	16	15	150	780	0.05	12.00
	10SS22M	10	22	150	780	0.05	11.00
	6SS33M	6.3	33	150	780	0.05	10.40
C'	20SS10M	20	10	100	1150	0.06	10.00
	20SS15M	20	15	100	1230	0.06	15.00
	20SS22M	20	22	100	1230	0.06	22.00
	16SS33M	16	33	100	1230	0.06	26.40
	4SS68M	4	68	70	1430	0.06	13.60
D	20SS47M	20	47	60	1830	0.06	47.00
	16SS68M	16	68	50	2000	0.07	54.40
	10SS100M	10	100	40	2100	0.07	50.00
	4SS150M	4	150	40	2100	0.08	30.00
E	20SS100M	20	100	30	2740	0.07	100.00
	10SS150M	10	150	30	2780	0.07	75.00
	6SS220M	6.3	220	30	3000	0.07	69.30
F	20SS150M	20	150	30	3200	0.07	150.00
	10SS330M	10	330	25	3500	0.07	165.00
	4SS470M	4	470	25	3500	0.07	94.00

※1 After 2 minutes

※2 100kHz, +45°C

Temperature coefficient for allowable ripple current

Ambient Temp.	$T_x \leq 45^\circ\text{C}$	$45^\circ\text{C} < T_x \leq 65^\circ\text{C}$	$65^\circ\text{C} < T_x \leq 85^\circ\text{C}$	$85^\circ\text{C} < T_x \leq 95^\circ\text{C}$	$95^\circ\text{C} < T_x \leq 105^\circ\text{C}$
Coefficient	1	0.85	0.7	0.4	0.25

Frequency coefficient for allowable ripple current

Frequency	$120\text{Hz} \leq f < 1\text{kHz}$	$1\text{kHz} \leq f < 10\text{kHz}$	$10\text{kHz} \leq f < 100\text{kHz}$	$100\text{kHz} \leq f \leq 500\text{kHz}$
Coefficient	0.05	0.2	0.5	1

Specifications for radial lead type

1. Part number system

1	6	S	L	4	R	7	M	+	T	S																																																										
Rated voltage		Series name		Rated Capacitance		Capacitance tolerance		Taping or forming of terminal code																																																												
↓		↓		↓		↓		↓																																																												
<table><tr><th>Rated volt.</th><th>Code</th></tr><tr><td>2.0</td><td>2</td></tr><tr><td>2.5</td><td>2R5 ※1</td></tr><tr><td>4.0</td><td>4</td></tr><tr><td>6.3</td><td>6</td></tr><tr><td>10</td><td>10</td></tr><tr><td>16</td><td>16</td></tr><tr><td>20</td><td>20</td></tr><tr><td>25</td><td>25</td></tr><tr><td>30</td><td>30</td></tr><tr><td>32</td><td>32</td></tr></table>		Rated volt.	Code	2.0	2	2.5	2R5 ※1	4.0	4	6.3	6	10	10	16	16	20	20	25	25	30	30	32	32	<table><tr><td>SC Series</td></tr><tr><td>SA Series</td></tr><tr><td>SL Series</td></tr><tr><td>SH Series</td></tr><tr><td>SP Series</td></tr><tr><td>SS Series</td></tr><tr><td>SEP Series</td></tr><tr><td>SEQP Series</td></tr><tr><td>SEPC Series</td></tr><tr><td>SF Series</td></tr></table>		SC Series	SA Series	SL Series	SH Series	SP Series	SS Series	SEP Series	SEQP Series	SEPC Series	SF Series	<table><tr><th>Rated Cap.(μF)</th><th>Code</th></tr><tr><td>1</td><td>1</td></tr><tr><td>2.2</td><td>2R2</td></tr><tr><td>4.7</td><td>4R7</td></tr><tr><td>10</td><td>10</td></tr><tr><td>22</td><td>22</td></tr><tr><td>100</td><td>100</td></tr><tr><td>220</td><td>220</td></tr><tr><td>1000</td><td>1000</td></tr><tr><td>2700</td><td>2700</td></tr></table>		Rated Cap.(μF)	Code	1	1	2.2	2R2	4.7	4R7	10	10	22	22	100	100	220	220	1000	1000	2700	2700	<table><tr><th>Cap. tolerance</th><th>Code</th></tr><tr><td>±20%</td><td>M</td></tr></table>		Cap. tolerance	Code	±20%	M	<table><tr><th>Taping or lead terminal wire process code</th></tr><tr><td>None suffix for regular length lead type products</td></tr></table>			Taping or lead terminal wire process code	None suffix for regular length lead type products
Rated volt.	Code																																																																			
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None suffix for regular length lead type products																																																																				

Example

※1 Code 2 is used for 2.5V products of E9 and F13 size in SEPC series.

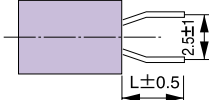
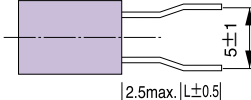
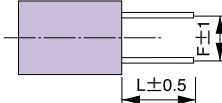
2. Lead terminal process

2-1. Applications

* The following table is a standard specification. Please contact us concerning other specifications.

Series	Size code	Bag-packed products (lead terminal cutting)			Taping
		Not processed	Forming cut	Straight cut	
Conductive polymer	SEP, SEQP	C6, E7, E12 F8, F13	×	+C3 +C3	+TSS +T
	SEPC	C6, C9, E9, E12 E13 F13	×	+C3 +C3 +C3	+TSS +TS +T
	SF	E1	×	×	+T, +TS
	SP	C', E', C, D, E F', F F0, G	×	×	+T, +TS +T ×
Organic semiconductor	SC, SH	A, B C, D, E F	+CA, +CC, +CD, +F, +F1, +F2 +F, +F1, +F2 ×	+C3 +C3 +C3	+T, +TS +T, +TS +T
	SA	C, D, E F G, H	+F, +F1, +F2 ×	+C3 +C3 ×	+T, +TS +T ×
	SL	A' B' C', E' F'	+CA, +CC, +CD, +F, +F1, +F2 +CA, +CC, +CD, +F, +F1, +F2 +F, +F1, +F2 ×	×	+T, +TS +T, +TS +T, +TS +T
	SS	A' B' C', D, E F	+CA, +CC, +CD, +F, +F1, +F2 +CA, +CC, +CD, +F, +F1, +F2 +F, +F1, +F2 ×	×	+T, +TS +T, +TS +T, +TS +T

2-2. Lead terminal cutting

Lead terminal cutting code	Process names	Size code (φD)	Dimensions (unit : mm)																				
+CA +CC +CD	Lead space : 2.5mm forming cut	A, A' (φ4) B, B' (φ5)	<div></div> <table><tr><td></td><td>CA</td><td>CC</td><td>CD</td></tr><tr><td>L</td><td>5.5</td><td>4.0</td><td>2.5</td></tr></table>						CA	CC	CD	L	5.5	4.0	2.5								
	CA	CC	CD																				
L	5.5	4.0	2.5																				
+F +F1 +F2	Lead space : 5mm forming cut	A, A' (φ4) B, B' (φ5) C, C', D (φ6.3) E, E' (φ8)	<div></div> <table><tr><td></td><td>F</td><td>F1</td><td>F2</td></tr><tr><td>L</td><td>5.5</td><td>4.5</td><td>3.0</td></tr></table>						F	F1	F2	L	5.5	4.5	3.0								
	F	F1	F2																				
L	5.5	4.5	3.0																				
+C3	Straight cut	A (φ4) B, B' (φ5) C, C', C6, C9, D (φ6.3) E, E', E7, E9, E12, E13 (φ8) F, F', F8, F13 (φ10)	<div></div> <table><tr><td></td><td>C3</td></tr><tr><td>L</td><td>3.5</td></tr></table> <table><tr><th>Size Code</th><th>A</th><th>B, B'</th><th>C,C',C6,C9,D</th><th>E,E',E7,E9,E12,E13</th><th>F, F', F8, F13</th></tr><tr><td>F</td><td>2.0</td><td>2.0</td><td>2.5</td><td>3.5</td><td>5.0</td></tr></table>						C3	L	3.5	Size Code	A	B, B'	C,C',C6,C9,D	E,E',E7,E9,E12,E13	F, F', F8, F13	F	2.0	2.0	2.5	3.5	5.0
	C3																						
L	3.5																						
Size Code	A	B, B'	C,C',C6,C9,D	E,E',E7,E9,E12,E13	F, F', F8, F13																		
F	2.0	2.0	2.5	3.5	5.0																		

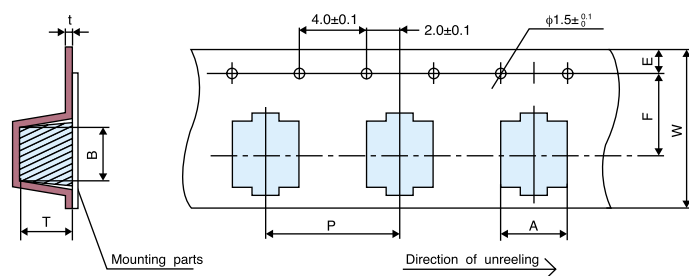
Specifications for SMD type

1. Part number system

1	6	S	V	P	3	R	3	M																																																
Rated voltage		Series name			Rated capacitance		Capacitance tolerance																																																	
↓		↓			↓		↓																																																	
<table><tr><th>Rated volt.</th><th>Code</th></tr><tr><td>2.5</td><td>2R5</td></tr><tr><td>4.0</td><td>4</td></tr><tr><td>6.3</td><td>6</td></tr><tr><td>10</td><td>10</td></tr><tr><td>16</td><td>16</td></tr><tr><td>20</td><td>20</td></tr><tr><td>25</td><td>25</td></tr><tr><td>35</td><td>35</td></tr></table>		Rated volt.	Code	2.5	2R5	4.0	4	6.3	6	10	10	16	16	20	20	25	25	35	35	<table><tr><th>S V P Series</th></tr><tr><td>SVQP Series</td></tr><tr><td>SVPA Series</td></tr><tr><td>SVPB Series</td></tr><tr><td>SVPC Series</td></tr><tr><td>SVPD Series</td></tr><tr><td>SVPS Series</td></tr><tr><td>SVPE Series</td></tr></table>			S V P Series	SVQP Series	SVPA Series	SVPB Series	SVPC Series	SVPD Series	SVPS Series	SVPE Series	Example <table><tr><th>Rated Cap.(μF)</th><th>Code</th></tr><tr><td>3.3</td><td>3R3</td></tr><tr><td>4.7</td><td>4R7</td></tr><tr><td>10</td><td>10</td></tr><tr><td>22</td><td>22</td></tr><tr><td>100</td><td>100</td></tr><tr><td>220</td><td>220</td></tr><tr><td>470</td><td>470</td></tr><tr><td>1500</td><td>1500</td></tr></table>		Rated Cap.(μF)	Code	3.3	3R3	4.7	4R7	10	10	22	22	100	100	220	220	470	470	1500	1500	<table><tr><th>Cap. tolerance</th><th>Code</th></tr><tr><td>±20%</td><td>M</td></tr></table>		Cap. tolerance	Code	±20%	M
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470	470																																																							
1500	1500																																																							
Cap. tolerance	Code																																																							
±20%	M																																																							

2. Taping

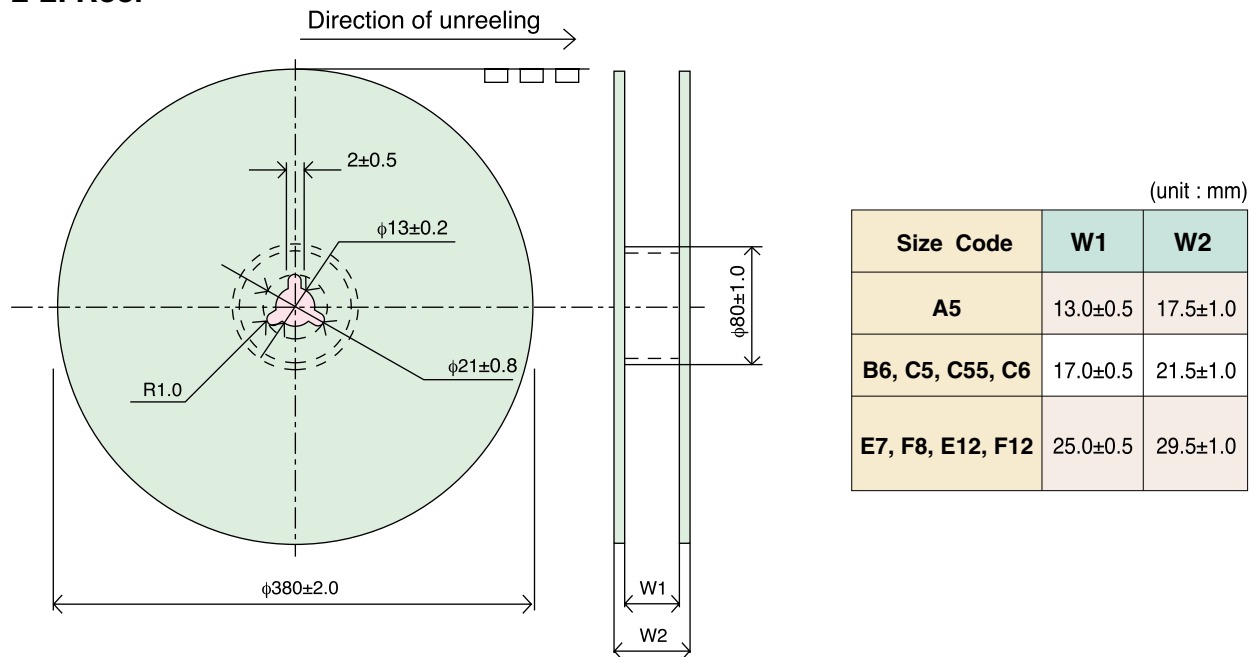
2-1. Carrier tape



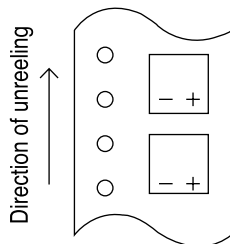
(unit : mm)

Dimension	A	B	W	F	E	P	t	T
Size code								
A5	4.7 ±0.2	4.7 ±0.2	12.0 ±0.3	5.5 ±0.1	1.75 ±0.1	8.0 ±0.1	0.4 ±0.1	5.8 ±0.2
B6	5.6 ±0.2	5.6 ±0.2	16.0 ±0.3	7.5 ±0.1	1.75 ±0.1	8.0 ±0.1	0.4 ±0.1	6.2 ±0.2
C5	6.9 ±0.2	6.9 ±0.2	16.0 ±0.3	7.5 ±0.1	1.75 ±0.1	12.0 ±0.1	0.4 ±0.1	5.3 ±0.2
C55	6.9 ±0.2	6.9 ±0.2	16.0 ±0.3	7.5 ±0.1	1.75 ±0.1	12.0 ±0.1	0.4 ±0.1	6.2 ±0.2
C6	6.9 ±0.2	6.9 ±0.2	16.0 ±0.3	7.5 ±0.1	1.75 ±0.1	12.0 ±0.1	0.4 ±0.1	6.2 ±0.2
E7	8.6 ±0.2	8.6 ±0.2	24.0 ±0.3	11.5 ±0.1	1.75 ±0.1	12.0 ±0.1	0.4 ±0.1	7.2 ±0.2
F8	10.7 ±0.2	10.7 ±0.2	24.0 ±0.3	11.5 ±0.1	1.75 ±0.1	16.0 ±0.1	0.4 ±0.1	8.2 ±0.2
E12	8.6 ±0.2	8.6 ±0.2	24.0 ±0.3	11.5 ±0.1	1.75 ±0.1	16.0 ±0.1	0.5 ±0.1	12.3 ±0.2
F12	10.7 ±0.2	10.7 ±0.2	24.0 ±0.3	11.5 ±0.1	1.75 ±0.1	16.0 ±0.1	0.4 ±0.1	13.0 ±0.2

2-2. Reel



2-3. Polarity



3. Minimum Packing Quantity

Taping type

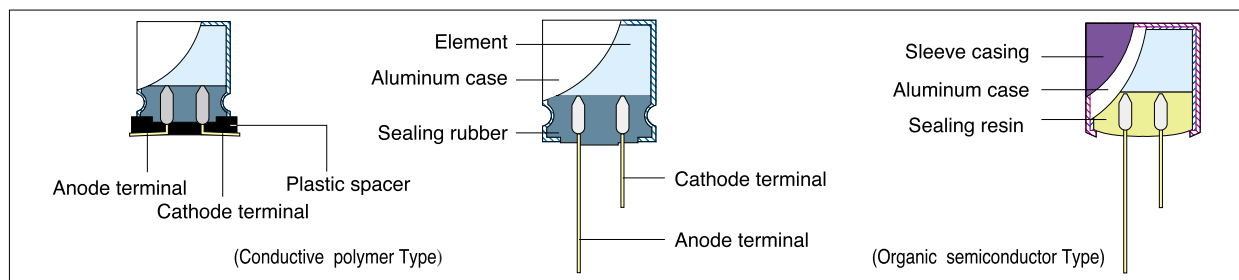
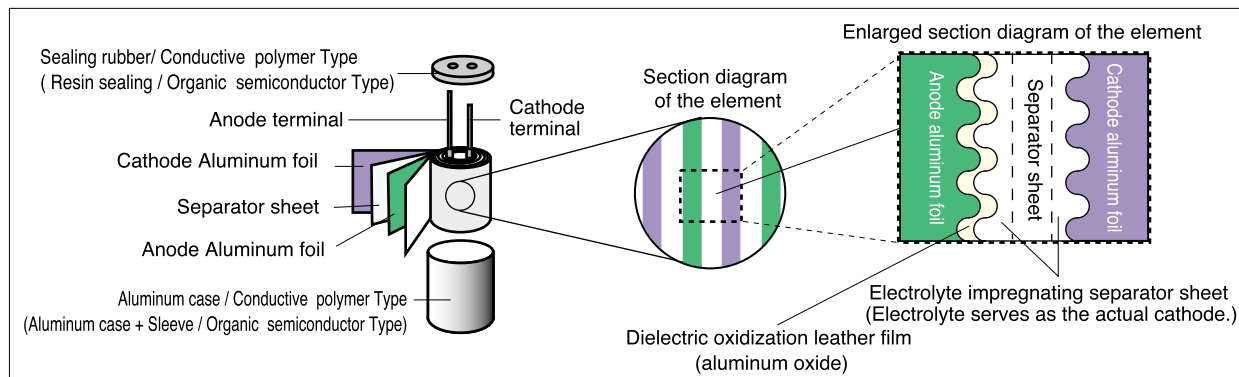
Size Code	pcs./Reel (φ380)
A5	2,000
B6	1,500
C5	1,300
C55	1,000
C6	1,000
E7	1,000
F8	500
E12	400
F12	400

1. Basic structure of OS-CON

OS-CON has a basic construction similar to an aluminum electrolytic capacitor.
A distinctive difference lies in **electrolyte**.

Aluminum electrolytic capacitor	Separator sheet (electrolyte) impregnated with electrolytic solution .	Liquid electrolyte
OS-CON (Organic semiconductor Type)	Separator sheet (electrolyte) impregnated with organic semiconductor .	Solid electrolyte
OS-CON (Conductive polymer Type)	Separator sheet (electrolyte) impregnated with conductive polymer .	Solid electrolyte

1-1. Basic construction

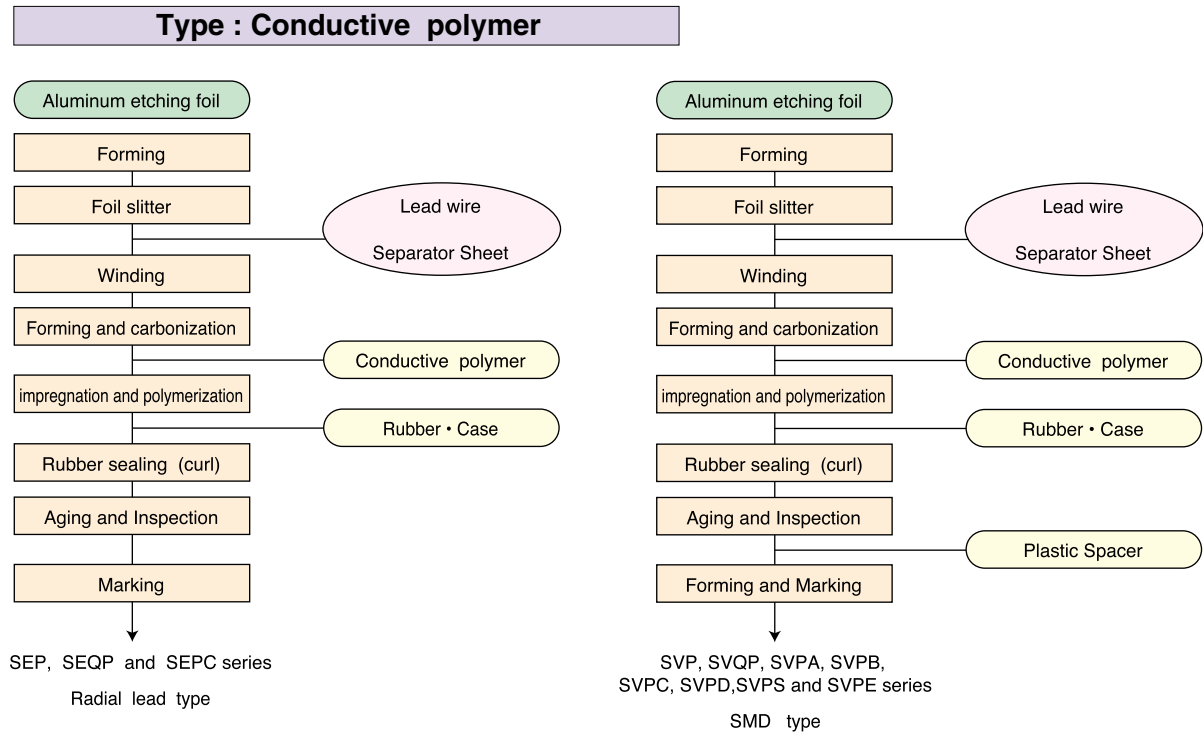


- Increased surface area of the aluminum electrode foil (high-speed processing to form rough surface) results in larger capacitance (greater charge density).
- Electrolyte is impregnated so that the rough dielectric aluminum oxide film at the anode aluminum foil sticks close to the cathode aluminum foil.
- Higher conductivity electrolyte is ideal.

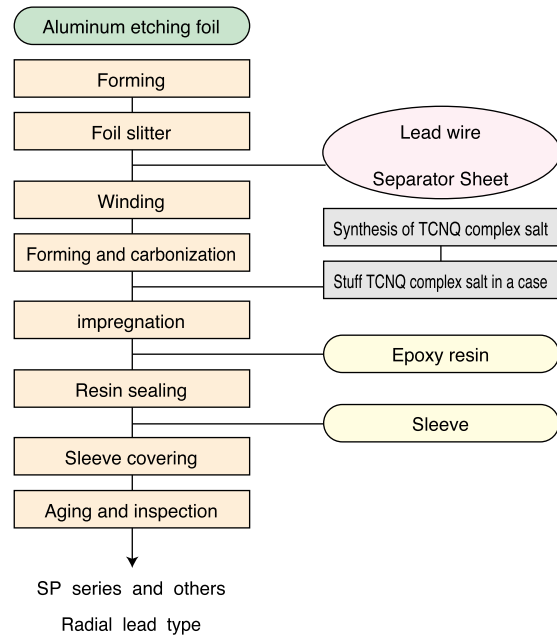
2. Differences of electrolyte and in characteristics between OS-CON and an electrolytic capacitor

	Aluminum electrolytic capacitor	OS-CON	
		Organic semiconductor Type	Conductive polymer Type
Conductivity (See P60,61)	3(mS/cm)	300(mS/cm)	3,000(mS/cm)
	<ul style="list-style-type: none"> Difficult to lower ESR due to ionic conduction ESR augments, in particular, in low temperature conditions 	<ul style="list-style-type: none"> High electronic conductivity facilitate to achieve low ESR ESR is stable in low temperature conditions 	<ul style="list-style-type: none"> The highest electronic conductivity, realizing super low ESR. ESR is stable in low temperature conditions
Reliability, lifespan (See P64,65)	<ul style="list-style-type: none"> Liquid electrolyte is evaporable at high temperature Static capacitance is on the decline at high temperature Limited lifespan resulting from dry-up Major fluctuations in temperature characteristics 	<ul style="list-style-type: none"> Solid electrolyte with little evaporation Less decrease in static capacitance Long lifespan even at high temperature Minor fluctuations in temperature characteristics 	<ul style="list-style-type: none"> Solid electrolyte with little evaporation Little decrease in static capacitance Long lifespan even at high temperature Very minor fluctuations in temperature characteristics
Temperature coefficient (See P66)	2 times by 10°C reduction	10 times by 20°C reduction	10 times by 20°C reduction
	105°C/2,000h→ 85°C/8,000h	105°C/2,000h→ 85°C/20,000h	105°C/2,000h→ 85°C/20,000h

3. OS-CON Manufacturing Method



Type :Organic semiconductor (TCNQ complex salt)



1. OS-CON Electrical Characteristics

1-1. Frequency Characteristics

Fig.A Impedance frequency characteristics compares OS-CON with the competitors.

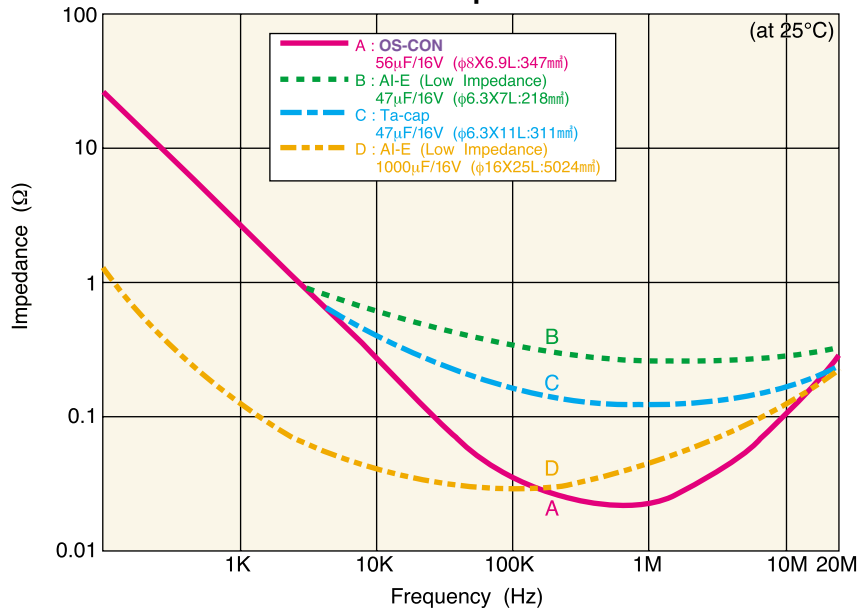
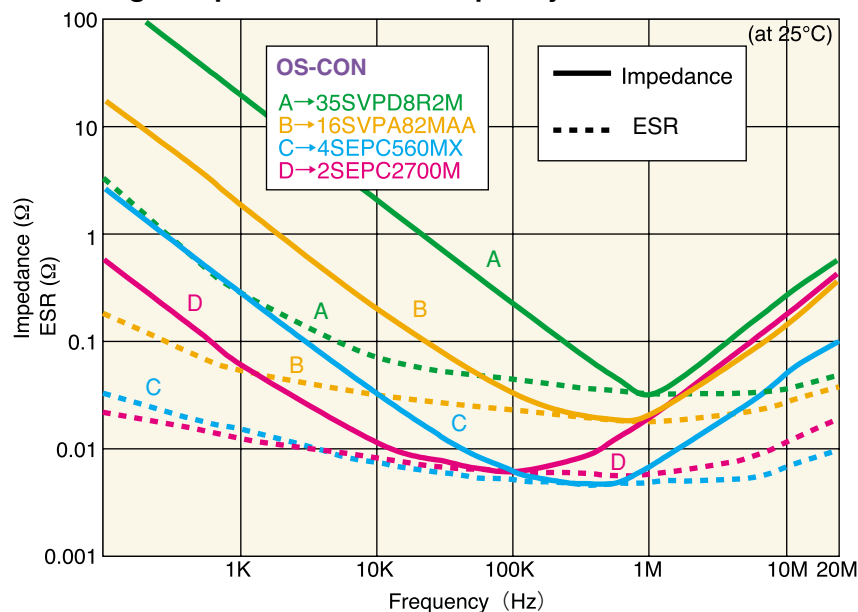


Fig.B Impedance & ESR frequency characteristics of OS-CONs

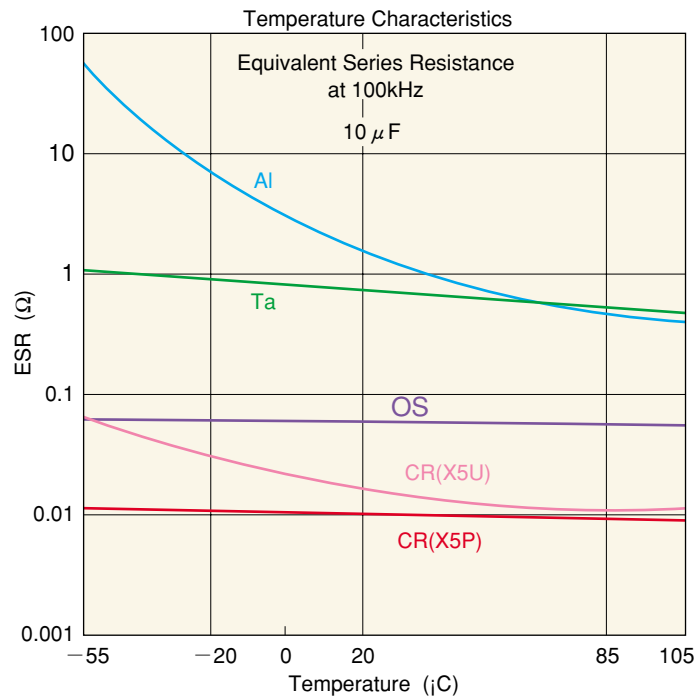


OS-CON is an electrolytic capacitor that has excellent frequency characteristics. It improves ESR greatly, and provides the excellent frequency characteristics because OS-CON use a high conductive polymer as electrolyte.

Fig.A: The OS-CON's frequency characteristic shows a nearly ideal curve. When compared at 100kHz, OS-CON 56 μ F, and low impedance aluminum electrolytic capacitor 1,000 μ F nearly have the same feature.

Fig.B: The resonance point of the OS-CON is at 100kHz to 10MHz. The ESR is an extremely small value approximately 5m Ω at 100kHz of 560 μ F.

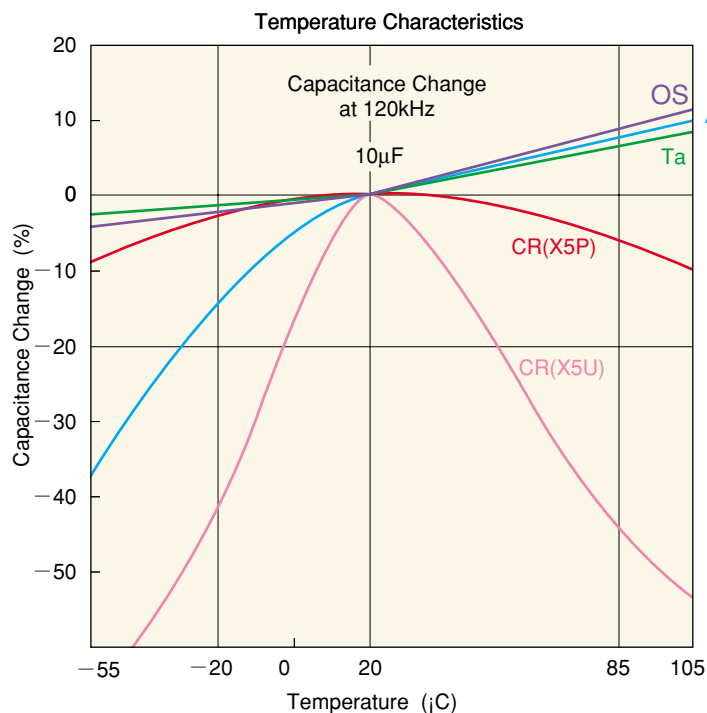
1-2. Characteristics at high temperature and low temperature



OS = OS-CON ————— Purple
 Al = AL-E. Cap ————— Blue
 Ta = Tantalum Cap. ————— Green
 CR(X5P) = Cera Cap. ————— Red
 (X5P Type)
 CR(X5U) = Cera Cap. ————— Pink
 (X5U Type)

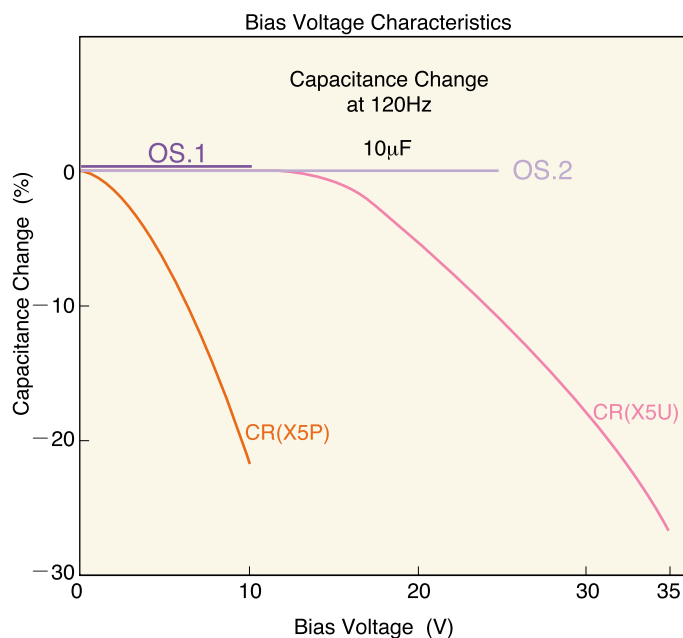
OS-CON's Characteristics at high temperature and low temperature is that it features little change in temperature for the ESR.

What ESR changes a little against temperature means that noise clearing ability changes a little against temperature as well. The OS-CON is suitable for outdoor apparatus.



1-3. Bias Characteristics

(a) Capacitance



OS.1 =OS-CON(10SVP10M) — Purple

OS.2 =OS-CON(25SVPD10M) — Light Purple

CR(X5P) =Cera Cap. — Red
(X5P Type ; 10V-10 μ F)CR(X5U) =Cera Cap. — Pink
(X5U Type ; 50V-10 μ F)

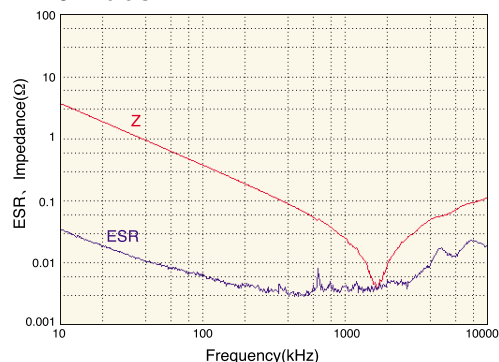
When voltage is applied to ceramic capacitors, they show a bias characteristics where static capacitance is reduced. Our **OS-CON** product, however, will show no reduction in capacitance for applied voltage within its rating (Note: our 25V product utilized temperature derated voltage).

(b) Impedance, ESR

Bias characteristics of OS-CON & Ceramic capacitors

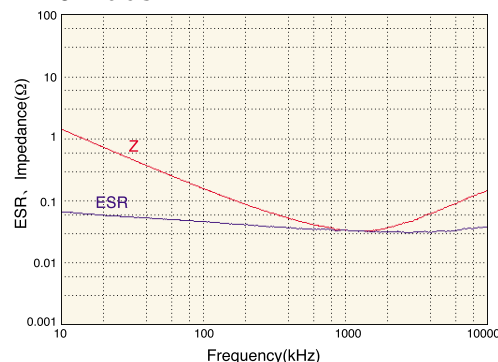
Multi-layer Ceramic capacitor (25V, 4.7 μ F)

0V bias

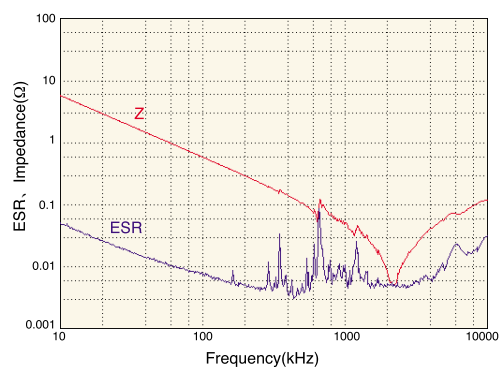


OS-CON (25SVPD10M)

0V bias

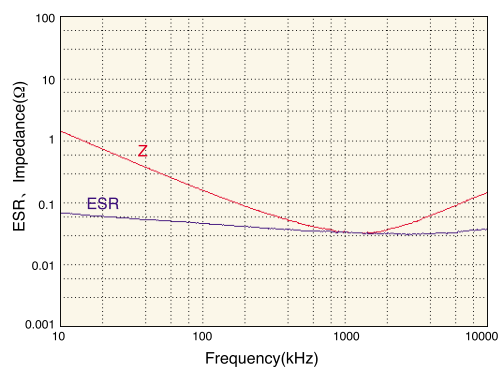
Multi-layer Ceramic capacitor (25V, 4.7 μ F)

20V bias



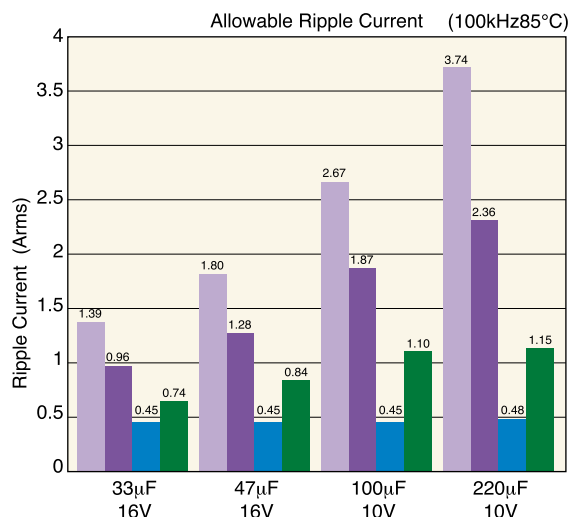
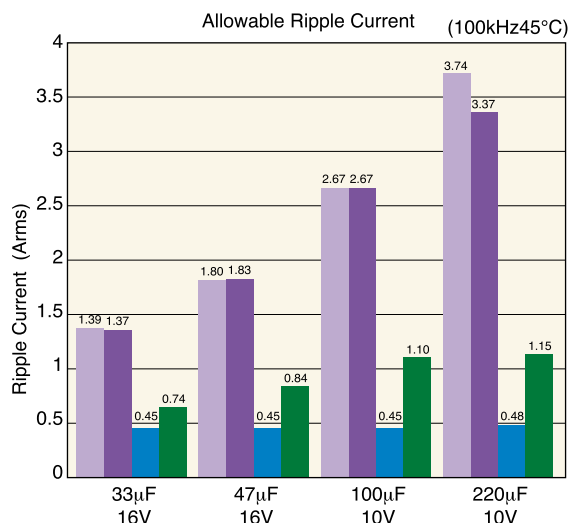
OS-CON (25SVPD10M)

20V bias



ESR & impedance of ceramic capacitors change largely between 300kHz to 1MHz. As for **OS-CON**, neither ESR nor impedance changes.

1-4. Allowable Ripple Current



When selecting smoothing capacitors for power supply, the allowable ripple current of the capacitor is one of the standard selections.

The allowable value of ripple current is decided by the generated heat of the capacitor, this heating is due to the ESR. Since a large ESR capacitor generates larger heat value, it can not make the flow of ripple current greater. Compared to other electrolytic capacitors, ESR of **OS-CON** is so small that it can allow far more ripple currents.

OS-CON (SVP series) — Light Purple
OS-CON (SA series) — Purple
Al-E. Cap. (Low Impedance) — Blue
Ta.Cap. (Low ESR) — Green

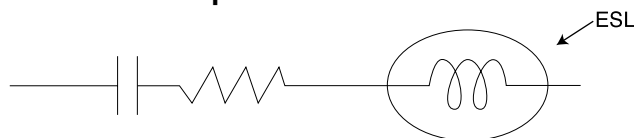
※SVP, SA series is almost same as the regulation.

1-5. ESL Characteristics

OS-CON is a capacitor of high performance with low ESR and large capacitance.

Recently in circuit technologies, the constituent of ESL is important in the domain of the high frequency with that of electronic equipment.

(a) Equivalent series circuit of capacitor



(b) Approximate ESL values of SEPC series

(unit : nH)

Size Code	at 10 MHz	at 40 MHz
C6	2.6	2.5
C9	2.2	2.1
E9	2.7	2.6
E12	4.3	4.1
E13	4.3	4.1
F13	6.0	5.8

※Measuring position: root of lead terminal

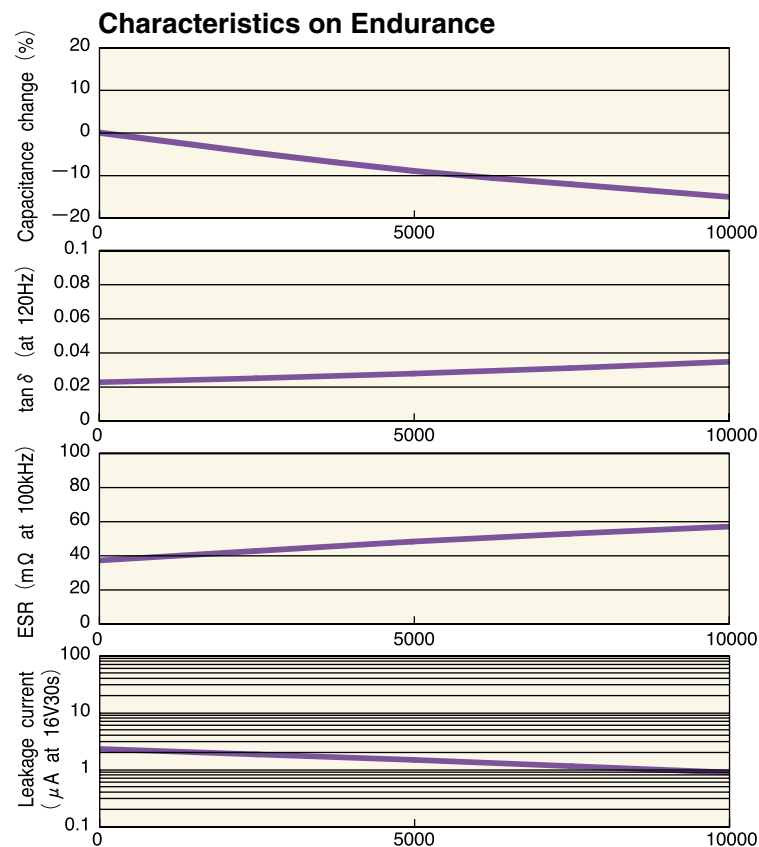
※Measuring method: Based on JEITA RC-2003

※All values on left figure are not guaranteed but reference.

Please contact SANYO for details of measurement.

1. Organic semiconductor (TCNQ complex salt) type (16SH33M)

1-1. Endurance (105°C, applied 16V)

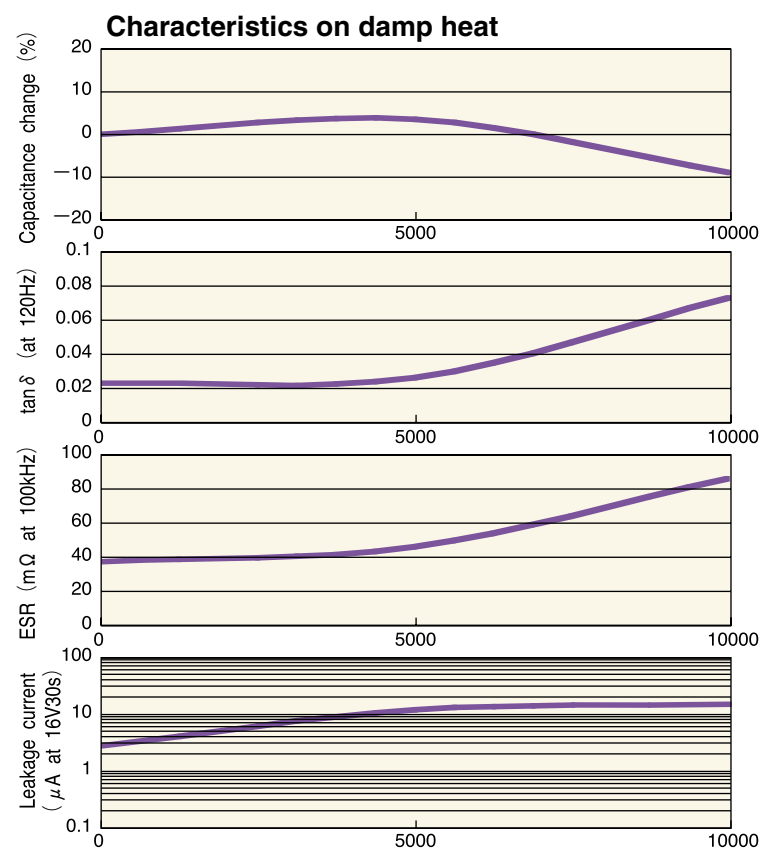


The tendency of capacitance change shows the same as an aluminum electrolytic capacitor.

An aluminum electrolytic capacitor has yield point time for dry-up of electrolytic solution, but **OS-CON** does not. Its capacitance decreases gradually which is semi-permanent.

These changes are little different whether voltage is applied or not except for leakage current.

1-2. Damp heat (60°C/90% RH, without load)



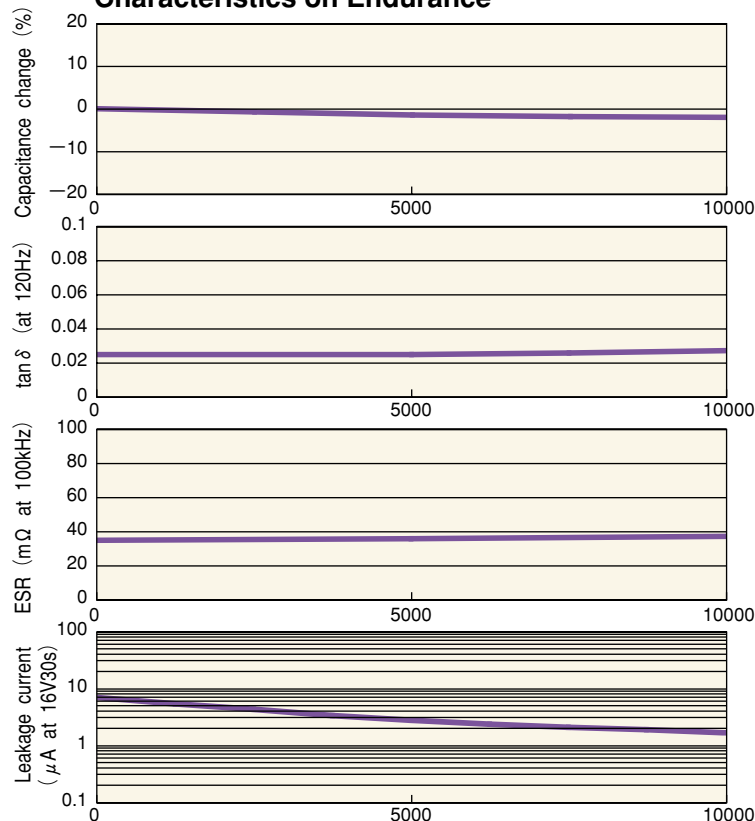
The characteristics have a little change compared with endurance.

It is necessary to note using **OS-CON** when it is damp heat environment such as outdoors.

2. Conductive polymer type (16SVP39M)

2-1. Endurance (105°C, 16V applied)

Characteristics on Endurance

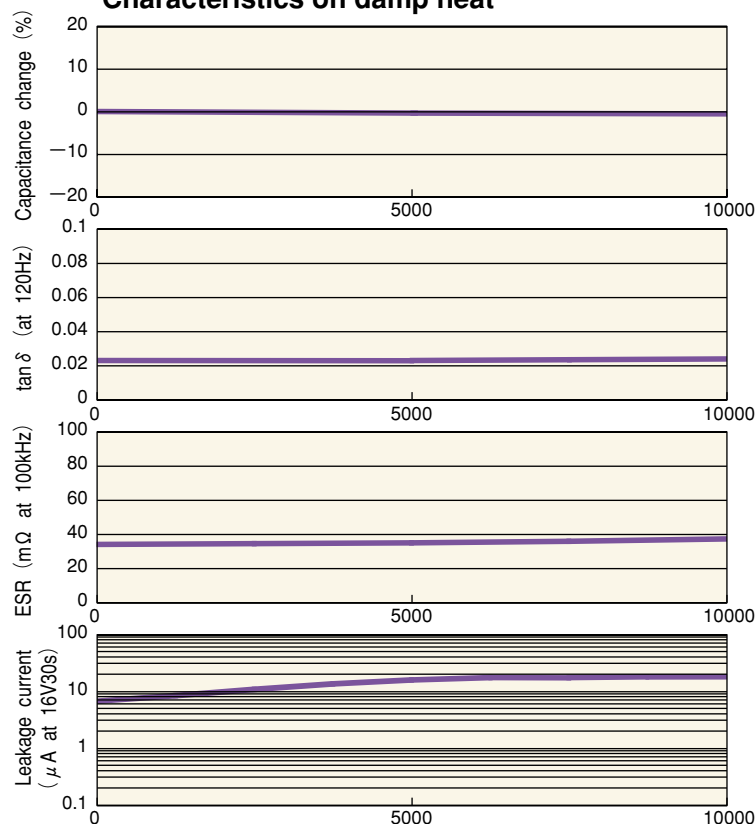


Little change in characteristics can be seen after 10,000 hours because of adoption of conductive polymer that excels in thermal stability.

The change in characteristic is very little compared with Organic semiconductor type.

2-2. Damp heat (60°C/90% RH, without load)

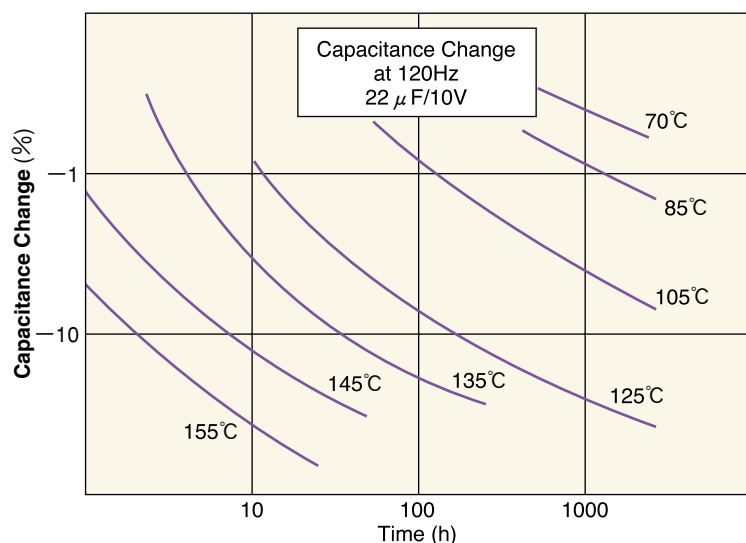
Characteristics on damp heat



Little change in characteristics can be seen after 10,000h hours in a high temperature and damp heat environment because of the excellent thermal stability of conductive polymer.

The change in characteristics is very little compared with Organic semiconductor type.

3. Temperature Acceleration Test (Endurance)



The decrease in capacitance of **OS-CON** depends on temperature.

The left figure shows the speed of capacitance decrease at each temperature. This graph indicates that temperature coefficient of **OS-CON** lifetime is 10 times by 20°C reduction.

Compare with this, aluminum capacitor lifetime is 2 times by 10°C reduction.

Estimation of life time

OS-CON	Aluminum electrolytic capacitor
105°C → 2,000h	105°C → 2,000h
95°C → 6,324h	95°C → 4,000h
85°C → 20,000h	85°C → 8,000h
75°C → 63,245h	75°C → 16,000h

※Guarantee temperature of **OS-CON** is 105°C, except for SEQP, SVQP and SVPD series.

※The following life time are not guaranteed but presumptive values.

Even if **OS-CON** and an aluminum electrolytic capacitor are guaranteed on 2,000 hours at 105°C, The life span results in differences as temperature drops.

OS-CON has a longer life span compared with an aluminum electrolytic capacitor.

4. Reliability Presumption of life

The capacitance of **OS-CON** is getting smaller as time goes by on Endurance described on P.62, 63,.

This means wear-failure of **OS-CON** is open mode, which is a main failure factor.

The life time is different by each operating temperature and self-heating by ripple current.

The following formula outline could make it possible to estimate the presumptive lifetime of **OS-CON** at ambient temperature T_x (°C).

The result of the following page estimation is not guaranteed but presumptive values based on actual measurement. The estimated life-span is limited up to 15 years.

4-1. Conductive polymer electrolyte type

$$L_x = L_o \times 10^{\frac{T_o - T_x}{20}}$$

L_x : Life expectancy (h) in actual use (temperature T_x)

L_o : Guaranteed (h) at maximum temperature in use

T_o : Maximum operating temperature

T_x : Temperature in actual use (ambient temperature of **OS-CON**) (°C)

Please contact us about the presumptive lifetime of **OS-CON** used at the ambient temperature of 105°C or higher, when the heat-proof characteristics of sealing rubber have to be factored in.

There is no need to apply a temperature-compensating coefficient for the ripple current in the conductive polymer electrolyte type.

The self-heating temperature under application of the rated ripple current

series	size	Self-heating
SVP,SVPA,SVPB,SVPC,SVPS,SVPE,SEP,SEPC	Except for A5, B6	approx. 20°C
SVP,SVPA,SVPC,SVPS	A5,B6	approx. 10°C
SVQP,SEQP,SVPD	All	approx. 2°C

※The estimated life expectancy of conductive polymer electrolyte type can be calculated without consideration of self-heating under application of the ripple current

4-2. Organic Semiconductive electrolyte type

$$L_x = L_o \times 10^{\frac{T_o - (T_x + \Delta T_x)}{20}}$$

L_x : Life expectancy (h) in actual use (temperature T_x)

L_o : Guaranteed (h) at maximum temperature in use

T_o : Maximum operating temperature

T_x : Temperature in actual use (ambient temperature of **OS-CON**) (°C)

ΔT_x : Self-heating temperature by Ripple current (°C)

$$\Delta T_x = (I_x / I_o)^2 \times \Delta T \quad I_x \leq I_o$$

I_o : Allowable ripple current at 45°C or less (Arms)

I_x : Actual flow of ripple current (Arms)

Note : The value of I_x should be below the value of I_o with the coefficient

Ambient Temp. (°C)	≤45	45 < T _x ≤ 65	65 < T _x ≤ 85	85 < T _x ≤ 95	95 < T _x ≤ 105
Coefficient	1.0	0.85	0.7	0.4	0.25

Self-heating value ΔT by maximum allowable ripple current (45°C or less) varies according to case size. Refer to the rough values in the chart below :

Case size	A, A'	B, B'	C, C'	D	E, E', E1	F, F', F ₀ , G, H
ΔT (°C)	8	10	15	16	18	20

5. Factors of Short Circuit Mode

(a) The factors of short circuit are as follows.

- (1) Applying voltage over the rated voltage.
- (2) Applying reverse voltage
- (3) Excessive mechanical stress
- (4) Applying an excessive surge current by sudden charge or discharge over the specification.

Please refer to "Guidelines and Precaution for Use" on Page 10 to 16.

1. Explanation of the excessive surge current suppression methods

When the **OS-CON** is used in the following circuit as figure 1, an excessive surge current may flow because the ESR is extremely small. Maintain the surge current at 10A or less.

If as long as 10 times of the allowable ripple current of the **OS-CON** exceeds 10A, reconfigure so that the ripple current does not exceed 10 times.

1-1. DC-DC converter input circuits

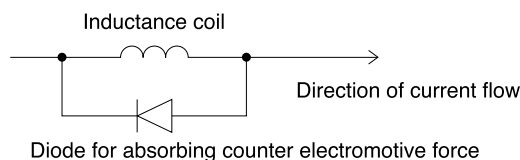
- (a) DC-DC converter circuits are usually a PCB block shape and use a low ESR capacitor in the input section for high performance and miniaturization.
- (b) Consideration must be given to the excessive surge current that flows from the equipment when the DC-DC converter is adjusted and inspected.

- ※ There is the possibility that an extremely large amount of an excessive surge current will flow through the **OS-CON** during voltage adjustment or inspection of the DC-DC converter's circuit block when the power impedance supplied from the equipment being adjusted or inspected is exceedingly low and the current suppression function of the current limiter and such is provided. (Refer to Figure 1)
- ※ An excessive surge current suppression measures must be taken for DC-DC converter adjustment and inspection equipment. (Refer to P. 69)

1-2. Circuits driven by chargeable batteries

- (a) Circuit power lines equipped with batteries or rechargeable batteries use capacitors such as the **OS-CON** with extremely low ESR to increase performance and facilitate miniaturization.

- ※ There is the possibility of an extremely large amount of an excessive surge current flowing through the low ESR capacitors arranged along the power line when the power is turned on for circuits driven by nickel cadmium chargeable batteries etc. that have a very low internal resistance. (Refer to Figure 1.)



- ※ A protection circuit like that is shown left is usually used to suppress surge current of charging battery.

- ※ The main points.

The peak current value of the diode when absorbing counter electromotive force.

1-3. An excessive surge current without protection resistor

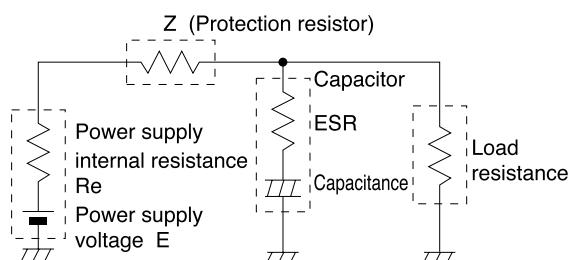
When there is no protection resistor Z as shown in Figure 1 and the power supply has R_e nearly = 0Ω , The **OS-CON** surge current is as follows.

$$\text{An excessive surge current (A)} = \frac{\text{Supplied DC voltage (E)}}{\text{ESR} + R_e + Z (\Omega)}$$

Example : For 25SC10M
ESR=90m Ω , or less and / Supplied DC voltage=20V,

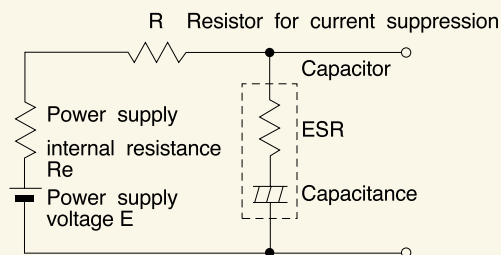
$$\frac{20\text{V}}{\text{less than } 0.09\Omega} = 222\text{A or more}$$

Fig. 1



2. Example of surge current suppression methods

2-1. Resistor method

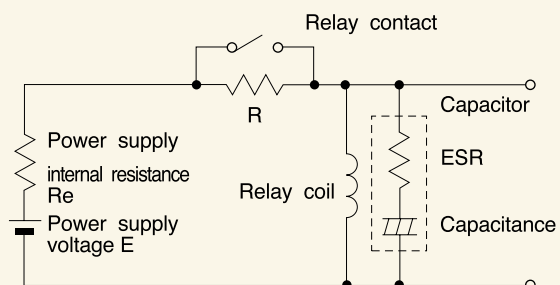


(a) Surge current is as shown below.

$$\text{Surge current (A)} = \frac{E \text{ (V)}}{R_e + \text{ESR} + R \text{ (}\Omega\text{)}}$$

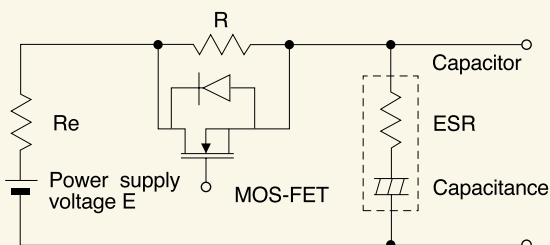
- (b) Surge current is usually determined mainly by R as R_e and ESR are low.
 (c) Although the current is simply and clearly suppressed with this method, resistor R for suppressing current causes the voltage to drop.

2-2. Resistor and relay method



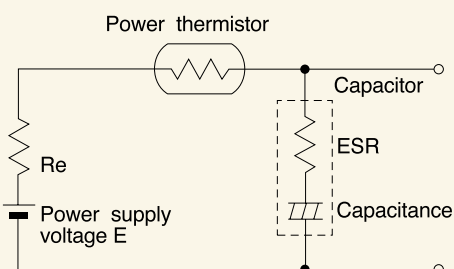
- (a) A surge current is exactly the same as in the resistor method. There is almost no voltage drop caused by the current suppression resistor from the time the relay contact goes on.
 (b) Note: After the capacitor has finished recharging, it may take some time or setting of voltage to turn the relay ON.

2-3. Resistor and MOS-FET method



- (a) A surge current is exactly the same as in the resistor method, there is almost no voltage drop caused by R after rushing, the same as the resistor and relay method.
 (b) Note: As with the resistor and relay method, after the capacitor has finished recharging, it may take some time or setting of voltage to turn the MOS-FET ON.

2-4. Power thermistor

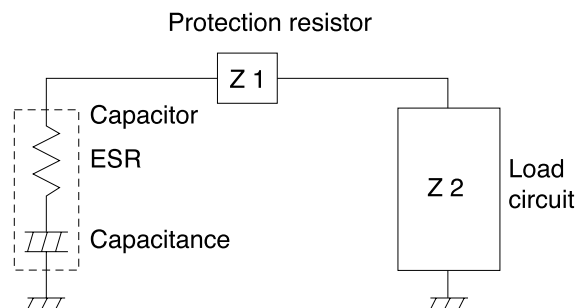


- (a) Taking an example of a common power thermistor, the value is 8Ω at 25°C , but becomes 0.62Ω at 130°C .
 (b) When the power thermistor is connected as shown in the above diagram, surge current is suppressed due to the large resistor value at the moment the switch is turned on. The output loss (voltage drop) is reduced after this.
 (c) The power thermistor has a heat constant, meaning that the large resistor value in the initial state cannot be regained the moment the switch is turned off. As a result, the ability to suppress current is lost when the switch is turned off and on quickly.

3. Sudden discharge current suppression

OS-CON has an exceedingly low ESR. When the load impedance during discharge is extremely low, there is the chance that it allows a large amount of discharge current to flow for an instant.

There is the chance an extremely large amount of discharge current will flow when electric charge is discharged with 0Ω loading.



※The discharge equivalent circuit is as shown to the left.

※The formula for estimating discharge current is given below.

$$\text{Discharge current (A)} = \frac{\text{Charging voltage (V)}}{\text{ESR} + Z1 + Z2 (\Omega)}$$

Example : For 25SC10M

- ESR=90mΩ or less
 - Charging voltage=20V
 - Z1, Z2=0Ω
- is set, then

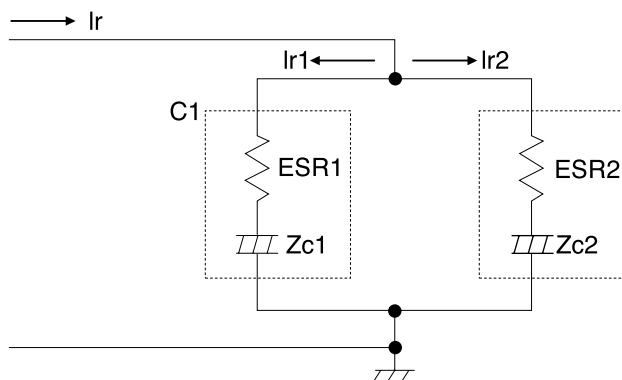
$$\begin{aligned} \text{Discharge current (A)} &= \frac{\text{Charging voltage } 20\text{V}}{\text{ESR } 0.09\Omega \text{ or less}} \\ &= 222\text{A or more} \end{aligned}$$

When the **OS-CON** is to be used in sudden discharge operations, configure the circuit so that the peak discharge current becomes 10A or less, using the above mentioned rough estimate expression as a guide. However, if 10 times the allowable ripple current of the **OS-CON** exceeds 10A, reconfigure so that 10 times the allowable ripple current is not exceeded.

4. Precautions when connecting an OS-CON and an aluminum electrolytic capacitor in parallel

Aluminum electrolytic capacitors and OS-CON are often connected in parallel to improve circuit density and cost performance of ripple absorbing capacitors as follows.

Fig.1



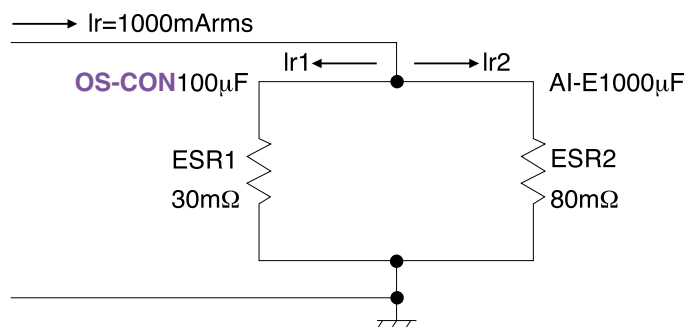
I_r : Total ripple current

ESR : Capacitor's equivalent series resistance

Z_c : Impedance of the capacitor's capacitive components

- Ripple current flowing through each parallelly connected capacitor can be found by using the values symbolized in the reference equivalent circuit in Figure 1.
- The equivalent circuit in Figure 1 can be simplified as shown in Figure 2 when it is to be used for frequencies between 100kHz and a few MHz. (Assuming the capacitor's capacitance is more than 10μF.)

Fig.2



Since impedance becomes exceedingly low when the capacity is more than 10μF. And frequencies higher than 100kHz, each Z_c in Figure 1 can be omitted changing the actual ripple current value to that shown in Figure 2.

Formula for calculating the ripple current value

$$I_{r1} = I_r \times \frac{ESR_2}{ESR_1 + ESR_2} = 1000\text{mA} \times \frac{80\text{m}\Omega}{30\text{m}\Omega + 80\text{m}\Omega} \doteq 727\text{mA rms}$$

- As shown here, although the OS-CON has 1/10th of the capacitance that of the mated capacitor, it allows 73% of the total ripple current to flow.
- When OS-CON and an aluminum electrolytic capacitor are to be used in parallel connection, select the appropriate type of OS-CON that has an extra margin of capacity since a large amount of ripple current flows through it.

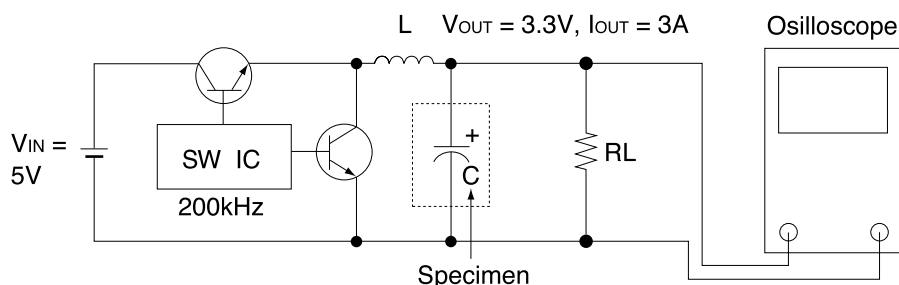
1. Voltage reduction capability of OS-CON

While there is a tendency to downsize switching power supplies capacitors still remain one of the parts occupying large areas of circuit boards. The working temperature is an important consideration when selecting a capacitor, since it generally results in widely varying capacitor characteristics. The following experiment shows the superior ripple removal capability of the OS-CON at higher frequencies in wide range of working temperature.

1-1. The number of capacitors needed to keep the same ripple voltage level

(a) Experiment content

A general chopper switching power supply was used to test the OS-CON against two alternatives. SANYO OS-CON, low-impedance aluminum electrolytic capacitor, and low-ESR tantalum capacitors were each connected as the capacitor in the output side smoothing circuit at working temperature range of -20°C, 25°C and 70°C to compare the output ripple voltage.



- (1) Initially SANYO OS-CON · 100uF/6.3V (6SVP100M · ϕ 6.3mm × L6.0mm) was used as the output side smoothing capacitor (C) in the above test circuit, the ripple voltage was measured at ambient temperature of each temperature. Refer to table 3.
- (2) Low-impedance aluminum electrolytic capacitors and Low-ESR tantalum capacitors were selected for measurement at each temperature so that the ripple voltage became equal to that achieved when the OS-CON · 100uF/6.3V was used. Refer to table 3.
- (3) The ripple voltage was measured at each temperature (-20°C to 70°C) with an equal number of side smoothing capacitors to the 25°C conditions, and the rates of change in the ESR of the smoothing capacitors were calculated from the amounts of change. Refer to table 2.

(b) Experiment result

Table1 On-board area ratios of capacitors at each temperature (when the ripple voltage is on the same level)

Ambient temperature	OS-CON	Aluminum Electrolytic capacitor	Tantalum capacitor
25°C	1	7.15	1.46
-20°C	1	16.7	1.46
70°C	1	4.77	1.46


Table2 Rates of change in ESR on the basis of 25°C(※)

Ambient temperature	OS-CON	Aluminum Electrolytic capacitor	Tantalum capacitor
25°C	1	1	1
- 20°C	1.14	3.03	1.27
70°C	0.952	0.587	0.85

$$\text{※Rate of change in ESR} = \frac{\text{Ripple voltage at ambient temperature} \times \text{Oscillation frequency at ambient temperature}}{\text{Ripple voltage at 25°C} \times \text{Oscillation frequency at 25°C}}$$

From the above results, it can be seen that SANYO OS-CON excels in temperature characteristics.

Table3 Measurement comparison at 25°C, -20°C and 70°C

Ambient temperature	25°C		
Capacitor type	OS-CON	Aluminum Electrolytic capacitor	Tantalum capacitor
capacitance/voltage	100μF/6.3V	680μF/6.3V	100μF/10V
ripple voltage	22.8mV	23.8mV	24.8mV
Size (※1) (mm)	6.6 X 6.6	10.5 X 10.5	7.5 X 4.5
On-board area ratio	1	7.15	1.46
Oscillation frequency	200kHz		
Fig	Fig1	Fig2	Fig3
Quantity			
Ambient temperature	-20°C		
Capacitor type	OS-CON	Aluminum Electrolytic capacitor	Tantalum capacitor
capacitance/voltage	100μF/6.3V	680μF/6.3V	100μF/10V
ripple voltage	20.8mV	24.4mV	25.2mV
Size (※1) (mm)	6.6 X 6.6	10.5 X 10.5	7.5 X 4.5
On-board area ratio	1	16.7	1.46
Oscillation frequency	250kHz		
Fig	Fig4	Fig5	Fig6
Quantity			
Ambient temperature	70°C		
Capacitor type	OS-CON	Aluminum Electrolytic capacitor	Tantalum capacitor
capacitance/voltage	100μF/6.3V	680μF/6.3V	100μF/10V
ripple voltage	25.6mV	24.0mV	24.8mV
Size (※1) (mm)	6.6 X 6.6	10.5 X 10.5	7.5 X 4.5
On-board area ratio	1	4.77	1.46
Oscillation frequency	170kHz		
Fig	Fig7	Fig8	Fig9
Quantity			

※1 The base plate dimensions were taken as the maximum dimensions except for Ta.

Table1 Comparison at 25°C

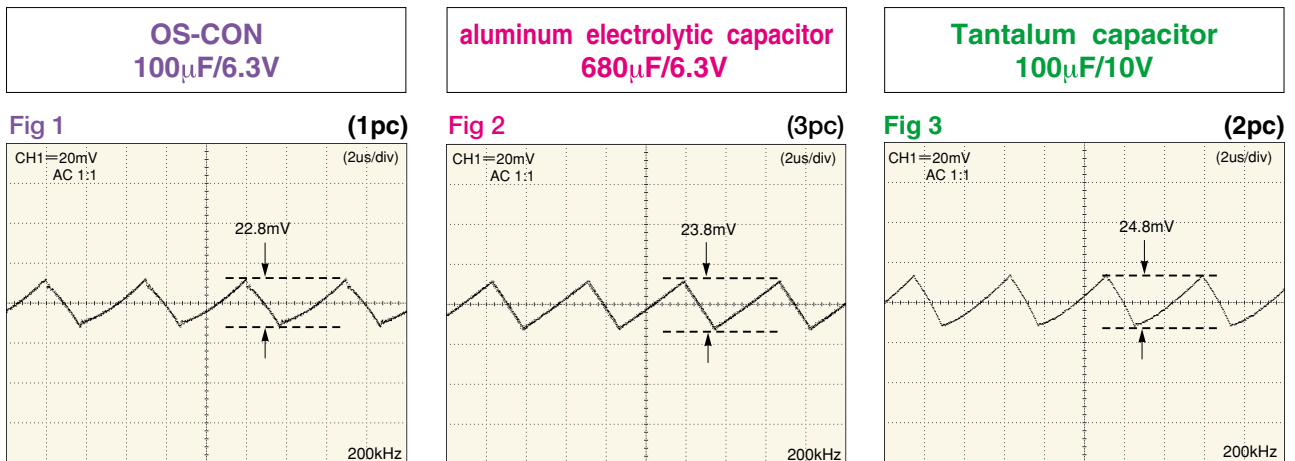


Table2 Comparison at -20°C

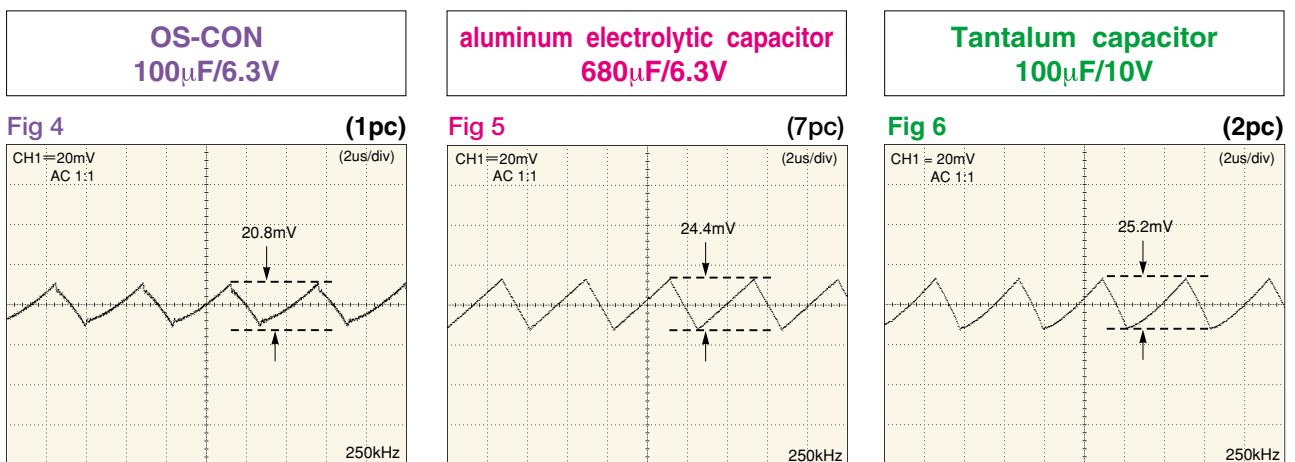
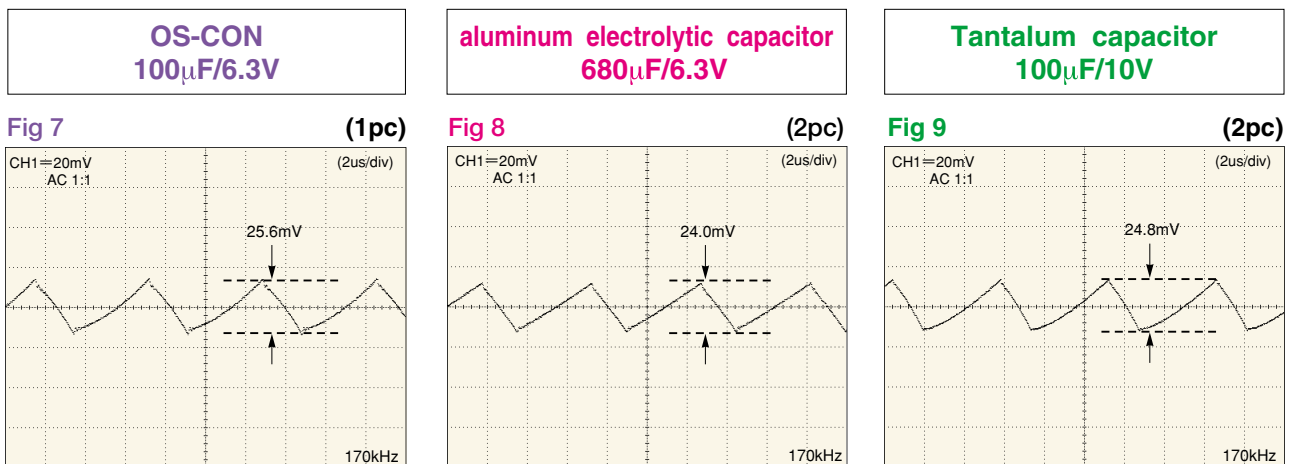


Table3 Comparison at 70°C

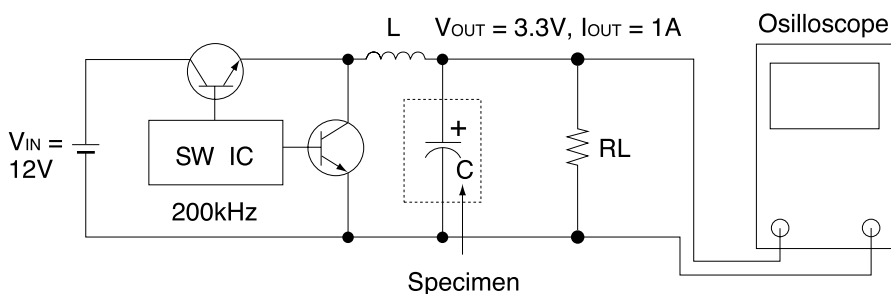


1-2. Ripple voltage removal capability before and after endurance test

(a) Experiment content

OS-CON and low-impedance aluminum electrolytic capacitors were respectively connected to the output side of chopper switching power supply, as soothing capacitors. Output ripple voltage made by the two kinds of capacitor was respectively measured before and after endurance tests (125°C×1000h, rated voltage applied) of the capacitors.

The ripple voltage measurement was done at the ambient temperatures of 25°C, 0°C, and -20°C.



OS-CON 56 μ F/10V (10SVDPD56M ϕ 6.3mm×L6mm) and low-impedance aluminum electrolytic capacitor 330 μ F /10V (ϕ 10mm×L10mm) were used for this experiment. Measured ESR value of the **OS-CON** was 38m Ω , while that of the aluminum electrolytic capacitor was 180m Ω . To match the equivalent ripple voltage one **OS-CON** brings, four pieces of the aluminum electrolytic capacitor were used.

$$\text{Output ripple voltage(outline)} = \frac{\text{Ripple current through coil}}{\text{ESR of capacitor}}$$

(1) Specifications of test samples

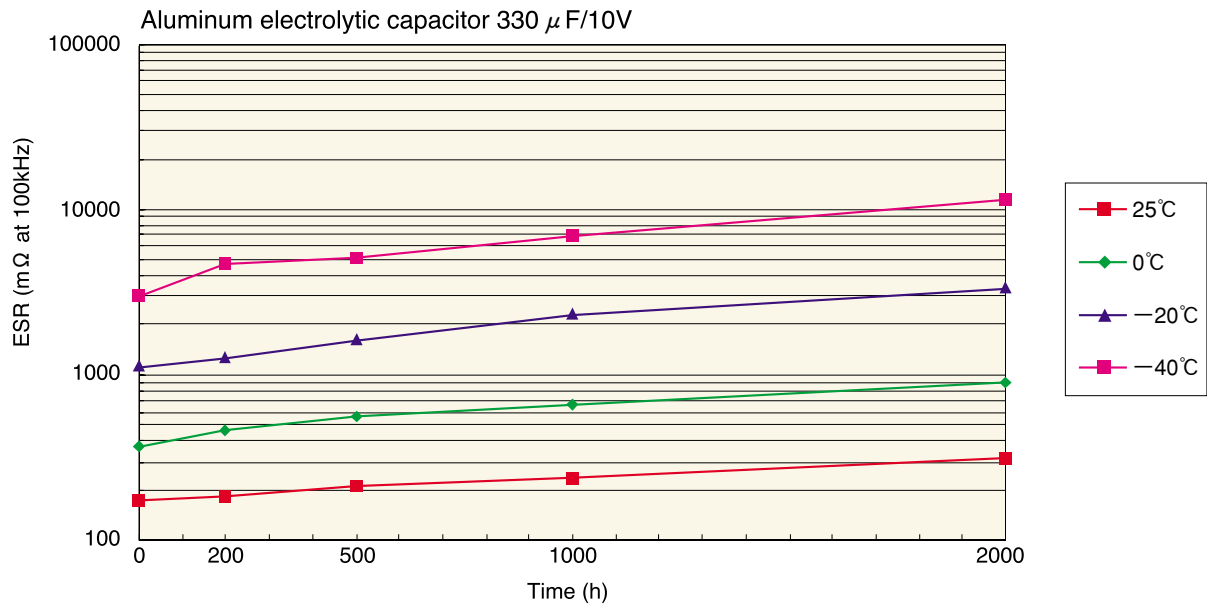
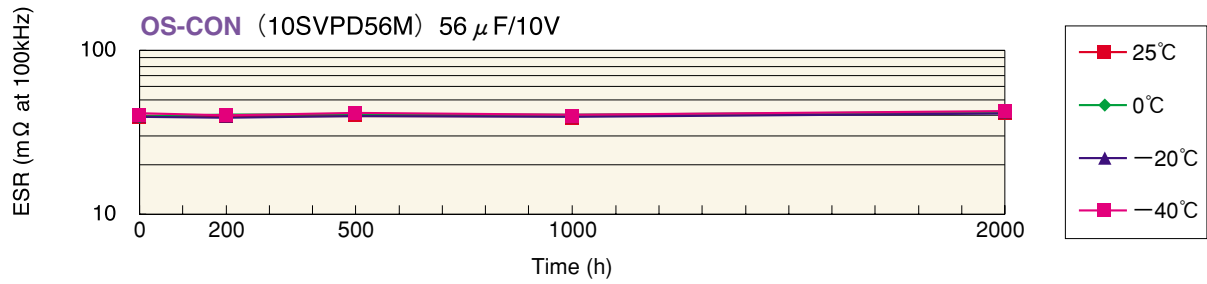
	OS-CON	Aluminum electrolytic capacitor
capacitance/voltage	56 μ F/10V	330 μ F/10V
ESR	45m Ω	300m Ω
Category temperature range	-55°C~+125°C	-40°C~+125°C
Endurance	125°C×2,000h	125°C×2,000h
Size(mm)	 ϕ 6.3×L6	 ϕ 10×L10

(2) ESR change of test samples

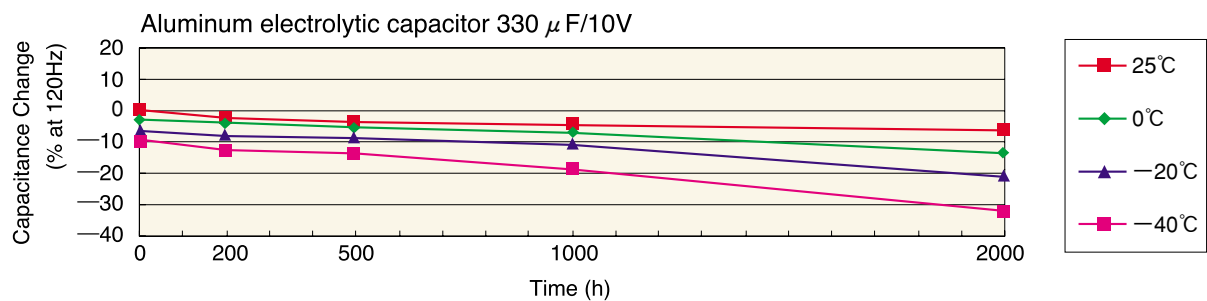
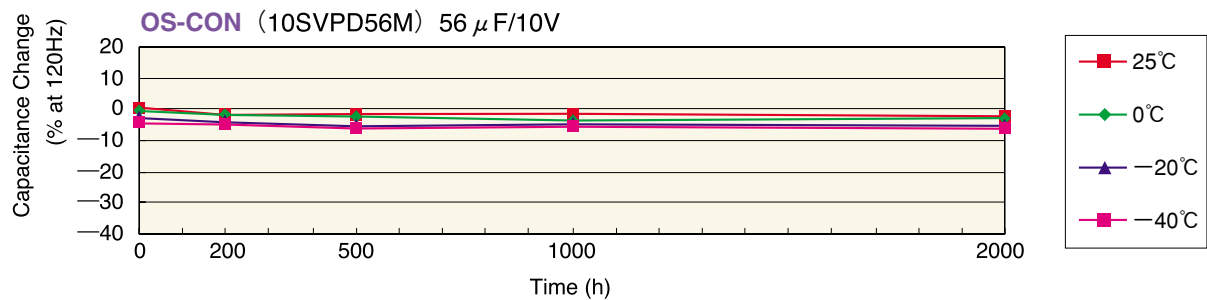
	OS-CON		Aluminum electrolytic capacitor	
Ambient temperature in measuring	Initial value	Value after 125°C×10V applied×1,000h	Initial value	Value after 125°C×10V applied×1,000h
25°C	38m Ω	40m Ω	180m Ω	231m Ω
0 °C	39m Ω	41m Ω	369m Ω	663m Ω
-20°C	38m Ω	40m Ω	907m Ω	2,212m Ω

(3) Endurance (125°C × 10V applied)

[ESR]



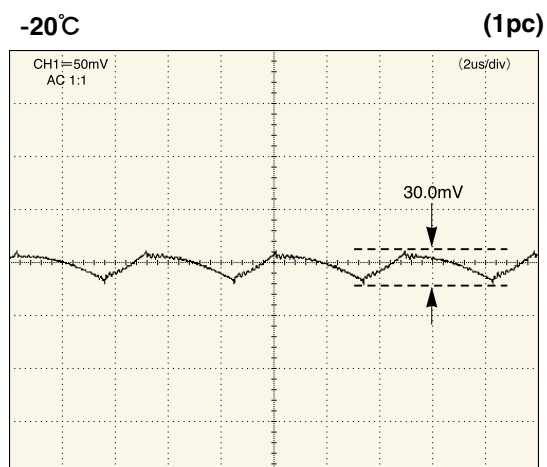
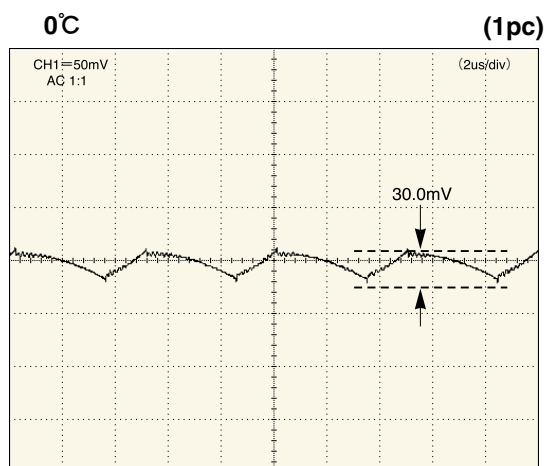
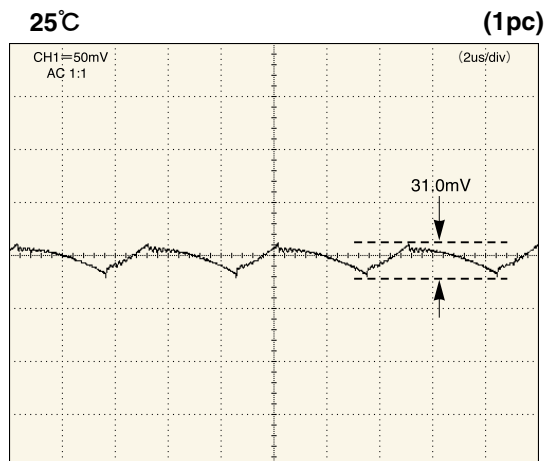
[Capacitance]



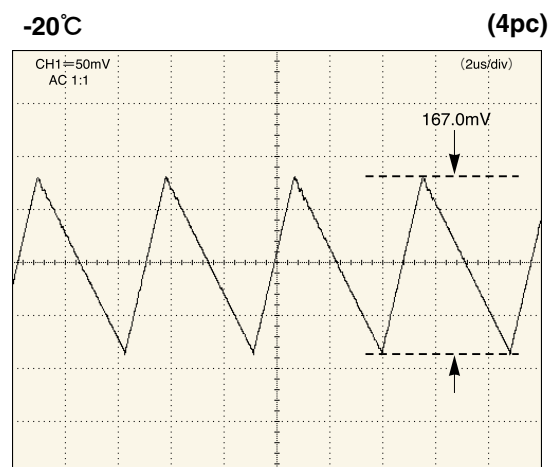
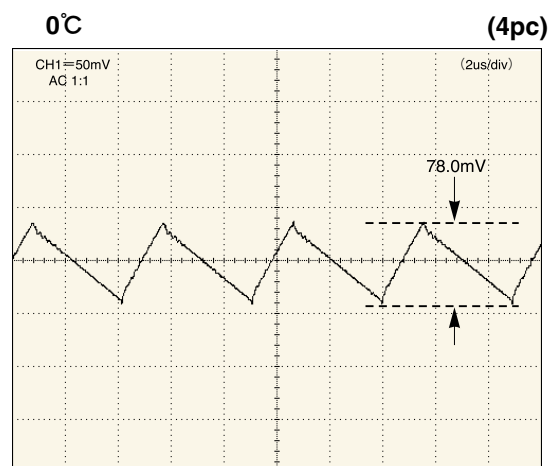
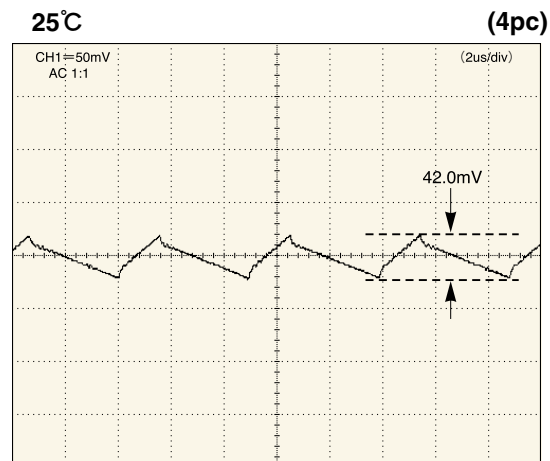
(b) Experiment result

(1) Initial ripple voltage waveform

OS-CON (10SVPD56M)
56 μ F/10V

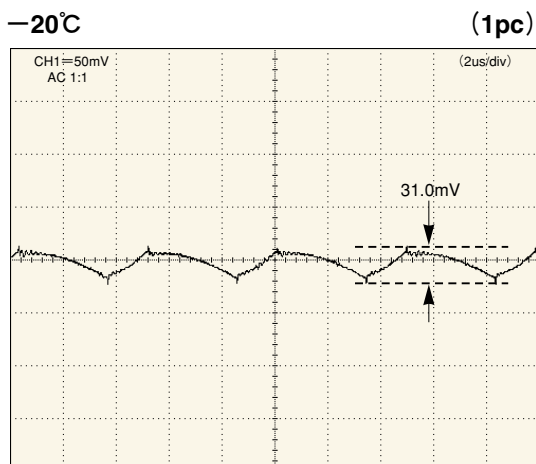
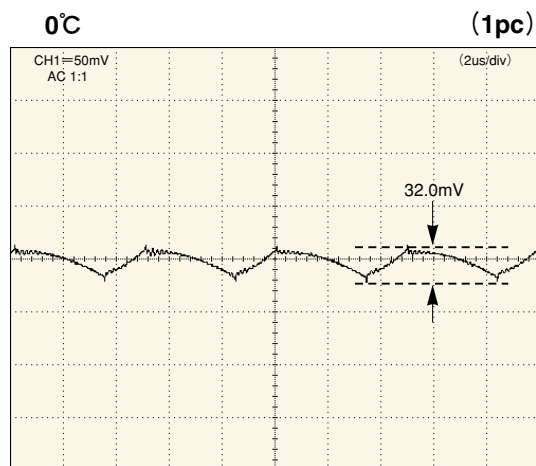
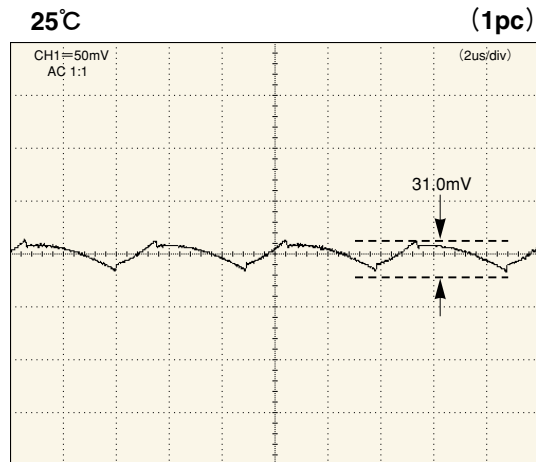
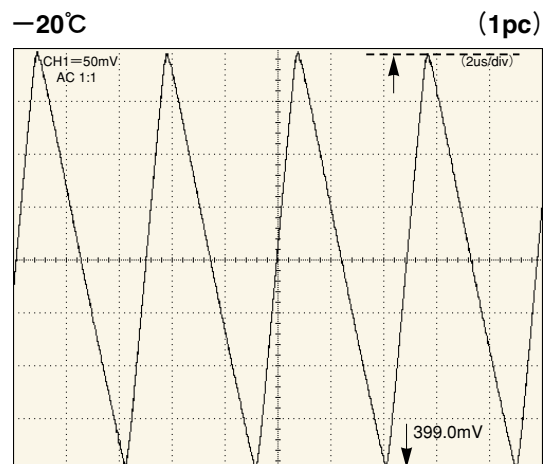
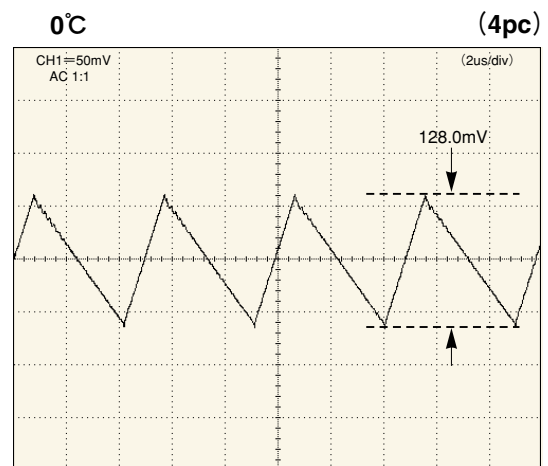
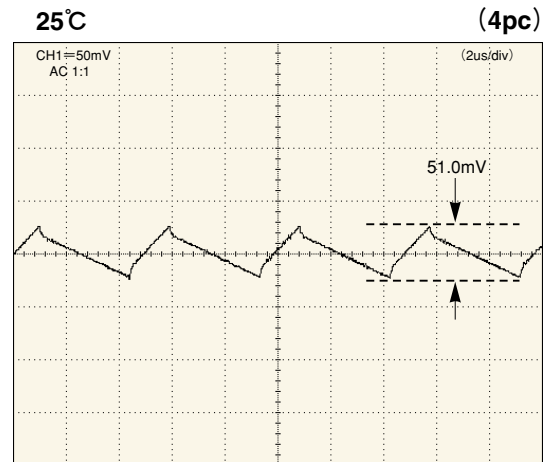


Aluminum electrolytic capacitor
330 μ F/10V



(2) Result

	OS-CON	Aluminum electrolytic capacitor
25°C	31mVp-p	42mVp-p
0 °C	30mVp-p	78mVp-p
-20°C	30mVp-p	167mVp-p

(3) Ripple voltage waveform after endurance test ($125^{\circ}\text{C} \times 10\text{V applied} \times 1000\text{h}$)**OS-CON (10SVPD56M)**
 $56 \mu\text{F}/10\text{V}$ **Aluminum electrolytic capacitor**
 $330 \mu\text{F}/10\text{V}$ 

(4) Result

	OS-CON	Aluminum electrolytic capacitor
25°C	31mVp-p	51mVp-p
0 °C	32mVp-p	128mVp-p
-20°C	31mVp-p	399mVp-p

2. OS-CON high speed back-up performance (Back-up capacitor for dynamic load)

IC, especially MPU that are lately used in electronic devices operate at very high processing speed.

PCB s are able to be more densely populated by lowering voltage and getting narrow pattern space.

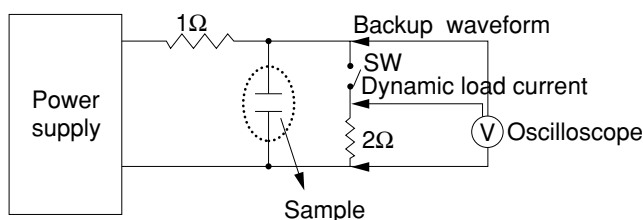
Involved in changing to lower voltage, load current is increasing with a development of new MPU. A sudden change of load current with larger dynamic load at high speed causes the voltage fluctuation of power supply line, and it makes MPU work wrong.

Capacitors with low ESR and large capacitance are necessary for high-speed load current transients. The **OS-CON** can provide the largest capacitance among low ESR capacitors, and in this regard, the **OS-CON** is a suitable back-up capacitor.

Let us explain the excellent back-up performance of **OS-CON** compared to that of other electrolytic capacitors.

2-1. Test condition

Test circuit

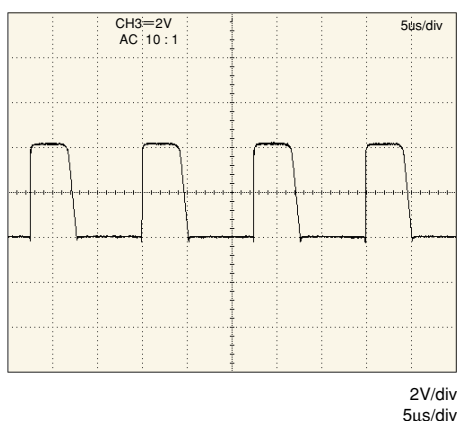


Load condition

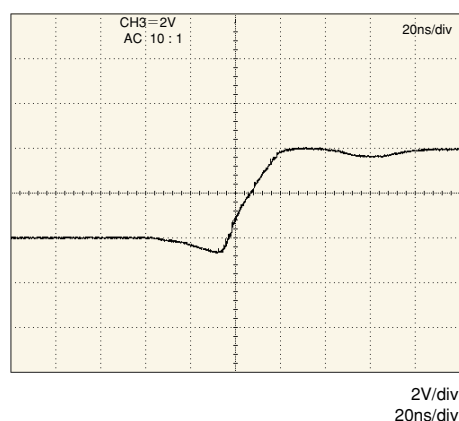
Item	Condition
Load width	5μs
Cycle	12.5μs
Rising time	20ns
Dynamic load current	2A
Voltage	4V
Power supply impedance	1Ω

(a) Switching wave form

Whole wave form



Rising wave form



Suitable back-up capacitor for an AC volt tolerance can be estimated from the following equation:

$$\Delta V = \frac{\Delta I \times \Delta t}{C} \times \frac{T - \Delta t}{T} + \Delta I \times \text{ESR}$$

ΔV : AC Volt tolerance (V)

C : Capacitance (F)

ΔI : Dynamic load current (A)

ESR : ESR (Ω)

Δt : Load width (s)

T : Cycle (s)

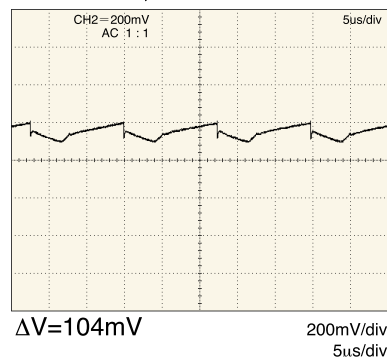
2-2. Result

(a) Comparison between OS-CON and other capacitors with same capacitance

Compared with same capacitance, **OS-CON** voltage drop of supply line is 104mV, but low-impedance Aluminum electrolytic capacitor indicates 548mV (5.3times of **OS-CON**), and low ESR Tantalum electrolytic capacitor indicates 212mV (2times of **OS-CON**).

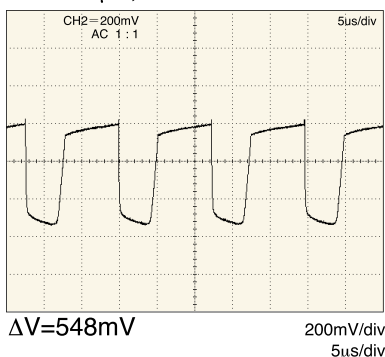
OS-CON

10SP100M, ESR : 21mΩ



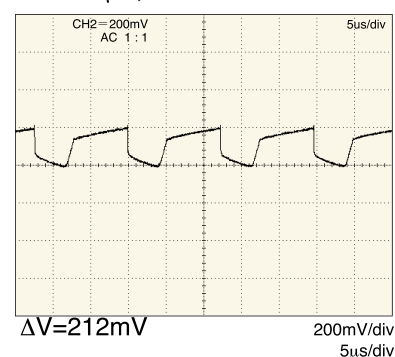
Low Z Aluminum capacitor

10V100μF, ESR : 245mΩ



Low ESR Tantalum capacitor

10V100μF, ESR : 85mΩ

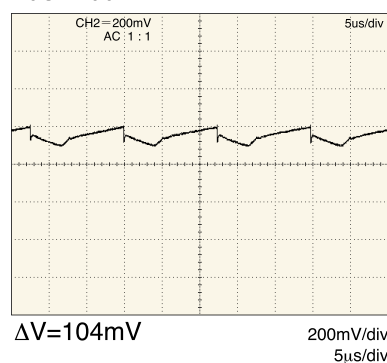


(b) Examination of same level variable load

To obtain similar level of voltage drop to 10SP100M, Low Z Aluminum electrolytic capacitor needs 1,500μF or more. Low ESR Tantalum electrolytic capacitor needs 220μF X 2pcs or more.

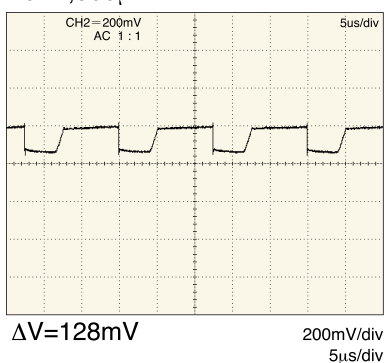
OS-CON

10SP100M



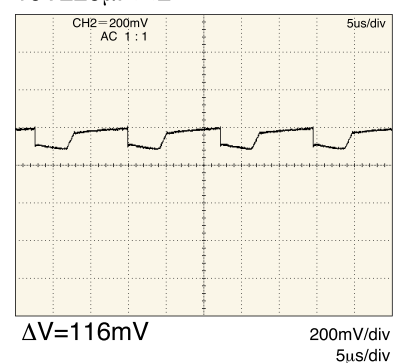
Low Z Aluminum capacitor

10V1,500μF



Low ESR Tantalum capacitor

10V220μF X 2

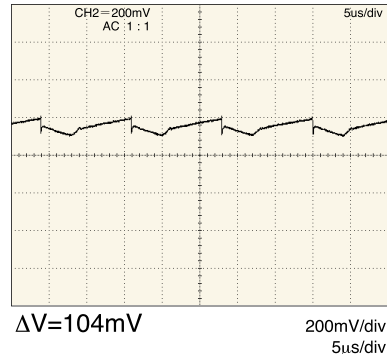


(c) Comparison with lower temperature (-20°C) of (b)

Compared them under the lower temperature, **OS-CON** is able to keep stable, while the low Z aluminum capacitor has 3.2 times larger drop of the voltage and the low ESR tantalum capacitor has 1.2 times larger drop of the voltage.

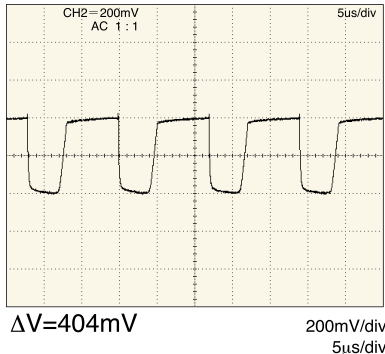
OS-CON

10SP100M



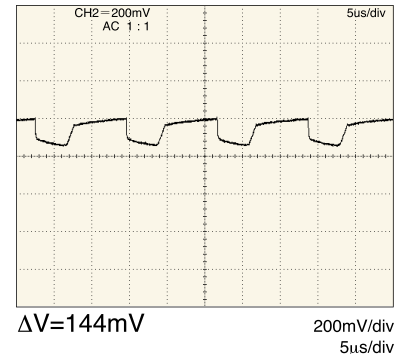
Low Z Aluminum capacitor

10V1,500μF



Low ESR Tantalum capacitor

10V220μF X 2



3. Application to low-pass filter circuits

As a means of removing noise from power supply lines, a low-pass filter such as shown below may be used. In recent years, switching power supplies have become a main power source, that are compact and highly efficient, but they make a large noise source. Also, digital circuits make noise easily, and in most of the devices with mixed noise-sensitive analog circuits, entry of high-frequency noise into the analog circuits is prevented by connecting these low-pass filters to the power supply lines of the analog circuits.

Fig.1 LC Filter

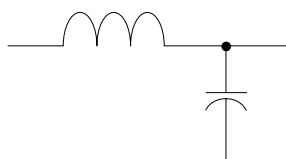
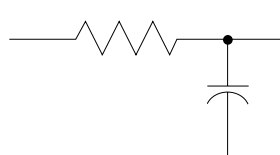


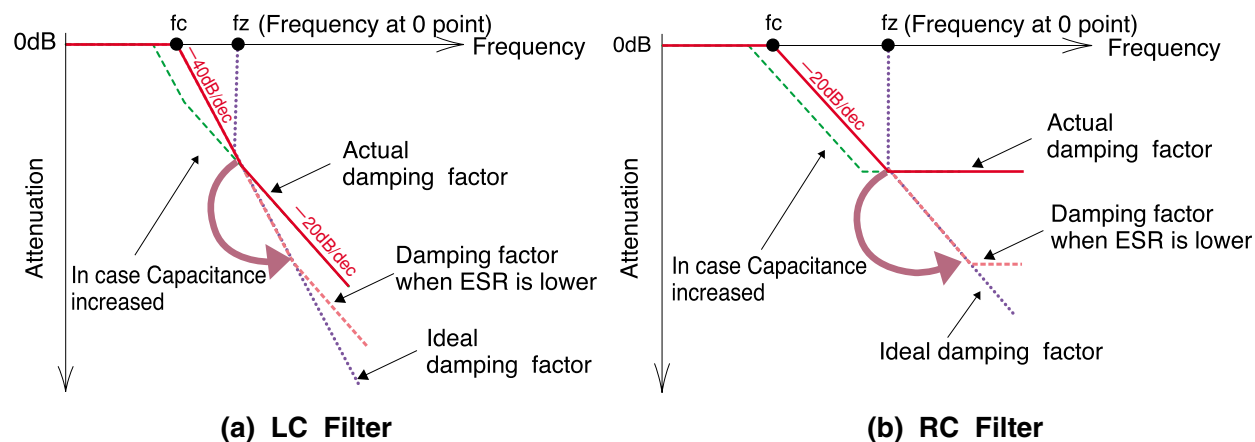
Fig.2 RC Filter



- (a) The damping effect of the filter gets closer to an ideal damping rate as capacitor has lower ESR.
- (b) Capacitance and ESR have 0 point frequency (f_z), when the frequency is higher than 0 point frequency, $+20\text{dB/dec}$ cancel the damping effect.
- (c) LC filter : -40dB/dec is to be -20dB/dec
RC filter : -20dB/dec is to be 0 (non-damping effect)
- (d) Even if capacitance is increased, there has no effect of noise cutting, it is influenced by the 0 point frequency.

OS-CON is most effective in low-pass filter because of low ESR.

Fig.3 Actual damping factor

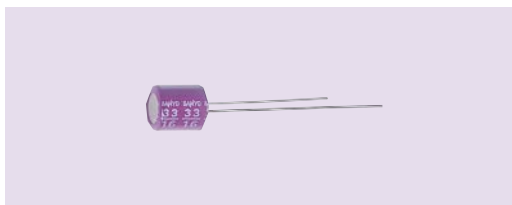


Compare the actual damping factor of the following OS-CON with an aluminum electrolyte capacitor on the next page

The capacitors used for comparison are as follows

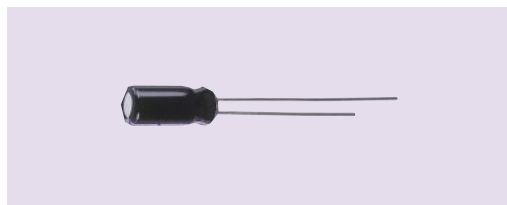
OS-CON (16SA33M)

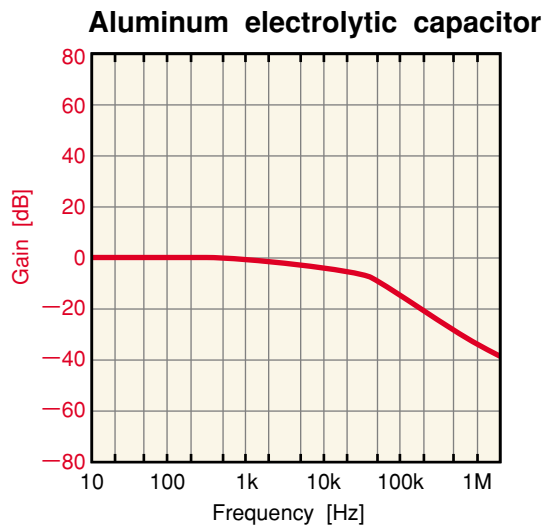
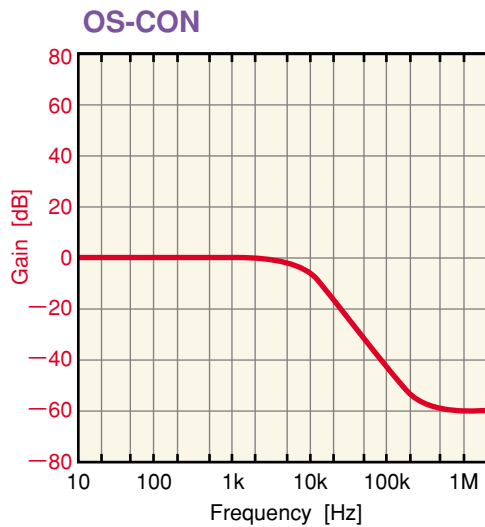
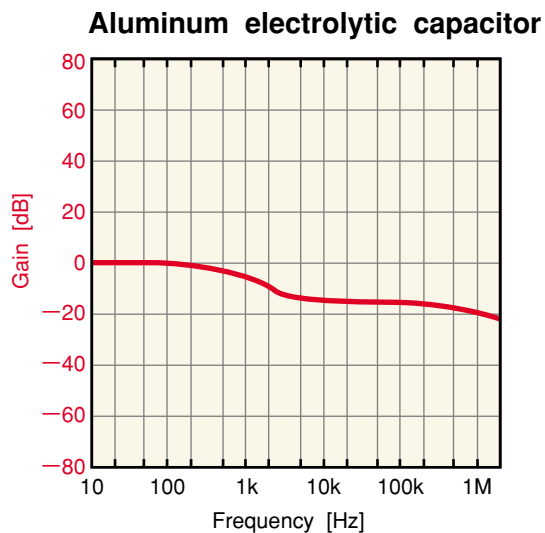
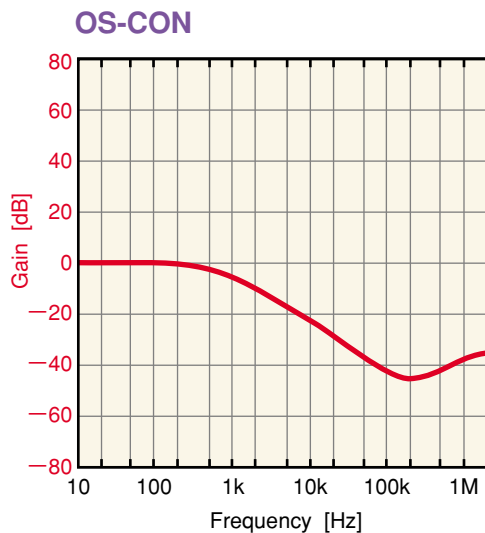
16V/33 μF , ESR=37m Ω (The actual measurement)



Aluminum electrolytic capacitor

10V/33 μF , ESR=1410m Ω (The actual measurement)



3-1. LC Filter (L=10uH)**3-2. RC Filter (R=5.6%)**

OS-CON shows a damping effect in higher frequency regions comparing with an aluminum electrolytic capacitor.

These measurements were made at room temperature. The difference in damping effect will be larger when the temperature is under 0°C, because ESR of an aluminum electrolytic capacitor will extremely increase. Oppositely **OS-CON** has little increase that does not affect the damping effect of the filter.

4. Application of switching power supply for smoothing capacitor

For restraining output ripple current, the output smoothing capacitor of the switching power supply is need to use low ESR capacitor. However the lower ESR capacitor makes the phenomenon sometimes occurs, which is called the abnormal oscillation of output voltage.

The abnormal oscillation of output voltage varies depending on the regulator method or the topology such as buck type, boost type, etc. We explain the mechanism and the treatment method of output voltage oscillation with the sample of the Buck style switching regulator under the voltage control mode.

4-1. Abnormal oscillation of output voltage

The switching power supply usually has the negative feed-back circuit to stabilize output voltage.

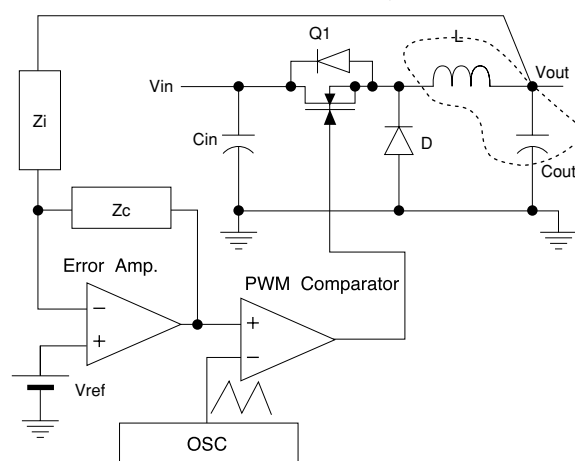
The difference between output voltage and standard voltage V_{ref} are amplified with the error amplifier and convert to the digital signal with the PWM comparator and flip on and flip off switch Q1.

Input voltage V_{in} becomes a square wave form by Q1, and you obtain DC output voltage V_{out} by make it smooth with coil L and capacitor C_{out} . L and also C_{out} assumed that they form the second low pass filters.

The frequency characteristics of the output LC filter is expressed with the Bode diagram like Figure 2.

The phase is delayed 180 degrees originally, because the error amplifier is a negative feedback circuit. Therefore, the phase delay of the output LC filter and the error amplifier occur at the same time, and when 360 degrees delay occur, the output voltage oscillates.

Fig.1 Control block of switching power supply



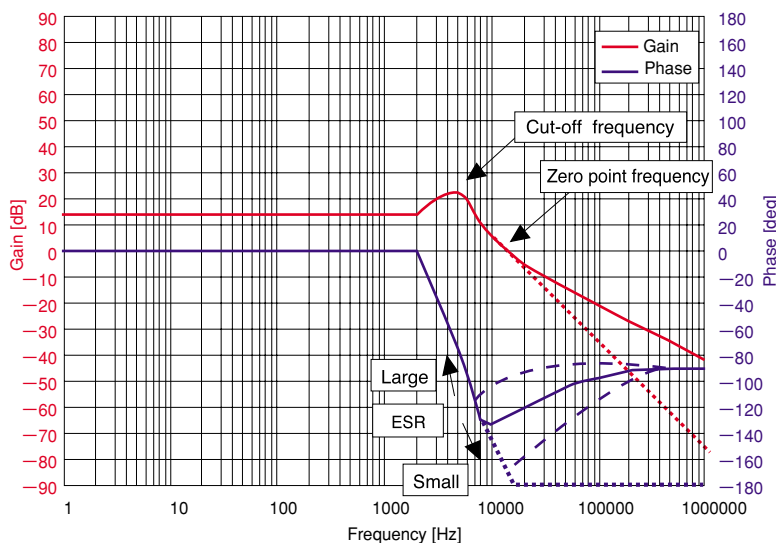
The damping rate of the LC filter is -40dB/dec and the cut-off frequency becomes $\frac{1}{2\pi\sqrt{LC}}$, and become Gain and Phase like the dotted line of Figure 2.

With an ideal filter the output voltage oscillates because it is delayed 180 degrees. But more than some frequency that is called zero frequency, damping rate of Gain becomes -40dB/dec to -20dB/dec . Furthermore the Phase returns to delay 90 degrees from delay 180 degrees. This is because the first order Phase lead network is formed by the capacitance value and ESR of C_{out} . Because, after the zero point frequency $\frac{1}{2\pi C_{out} ESR}$, the Gain damping rate goes on the Phase of $+20\text{dB}$, $+90$ degrees. However, when the low

ESR capacitor is used, it works as a LC filter up to high frequency band, and the phase delay to nearly 180 degrees and it becomes easy to oscillate.

30 degrees to 40 degrees or more of Phase margin is thought as a necessity to inhibit the oscillation of output voltage with a general negative feed-back circuit. The Phase margin is numerical value how much the minimum value of the Phase is distant from-180 degrees. The smaller the Phase margin gets, the higher the possibility to oscillate by the characteristic dispersion and temperature change of the component will be.

Fig.2 Frequency characteristic of LC filter



4-2. Inhibition method of oscillation

By doing Phase compensation with the feed-back circuit of the error amplifier the oscillation of output voltage can be inhibited.

There are various kinds in Phase compensation. It is most effective to use the Phase compensation circuit like the following in the switch power supply of the voltage control mode.

Figure 3 : ② & ④ form first order Phase lead network. ① & ③ form first order Phase lag network.

By adjusting these values, it does the Phase compensation by which Phase will occur and improve Phase delay of the whole negative feed-back circuit by the frequency characteristic of output LC filter at the frequency band which the Phase indicates the lowest.

Fig.3 Phase compensation network of Voltage Control Mode

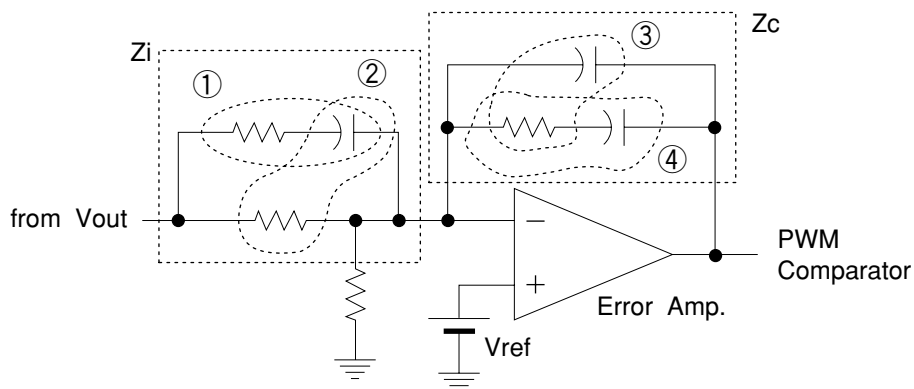
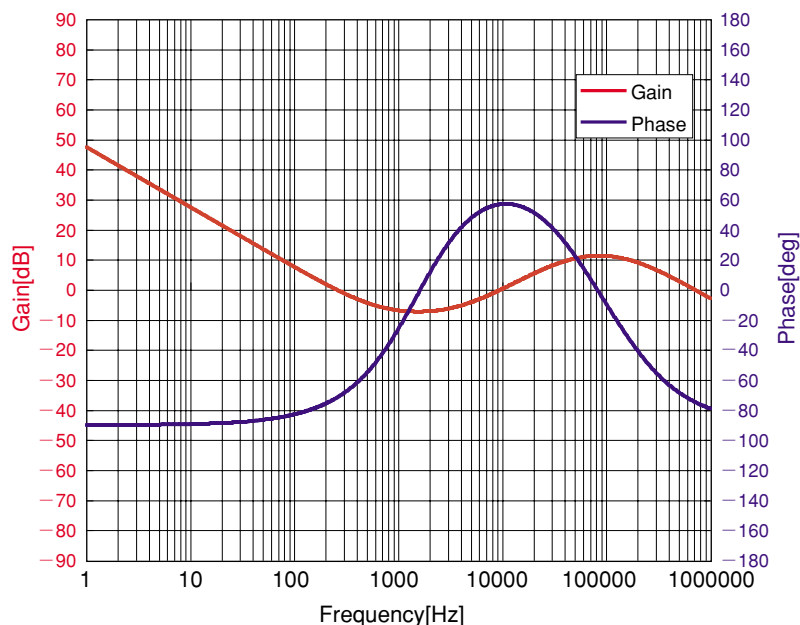


Figure 4 : Example. As the Phase of the output LC filter of Figure 2 becomes a lowest point at around 10kHz, it has about 30 degrees of Phase lead around that frequency. Because of this, it can secure the Phase margin of 30 degrees even if the Phase delay of LC filter becomes 180 degree nearly, the oscillation of output voltage can be inhibited.

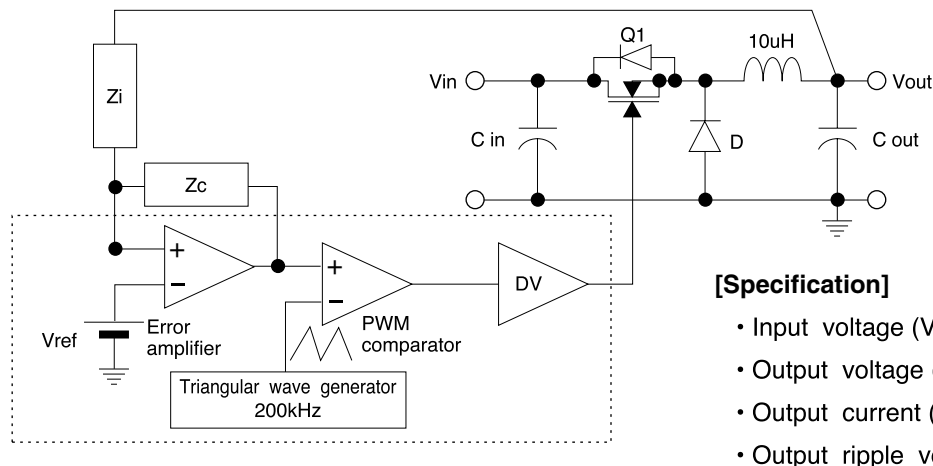
Related in detail, please inquire it to us.

Fig.4 Frequency characteristic of Phase Compensation Network



4-3. Concrete design examples of prevention oscillation

Fig.5 Step-down DC-DC converter design example



The ESR of the output capacitor necessary to make an output ripple voltage of 20mVp-p can be obtained as follows:

$$ESR < V_{ripple} / ((V_{in} - V_{out}) / L * V_{out} / V_{in} / f_{osc}) = 35.7m\Omega$$

Consequently, the following capacitors have been selected.

(a) OS-CON

6SPV100M 1-parallel $\phi 6.3 \times L6mm$ ESR = 32m Ω ※ESR is an actual measurement.

(b) Aluminum electrolytic capacitor

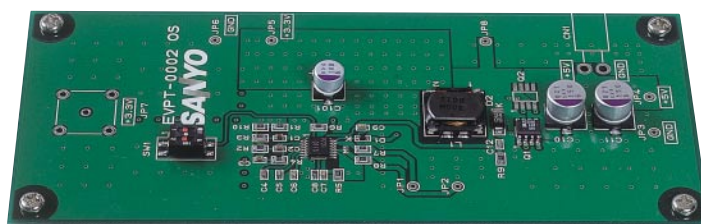
6V/680uF 3-parallel $\phi 10 \times L8mm$ ESR = 128m Ω /p. Total ESR = 43m Ω

Photograph 1: Measuring evaluation board using the above capacitors

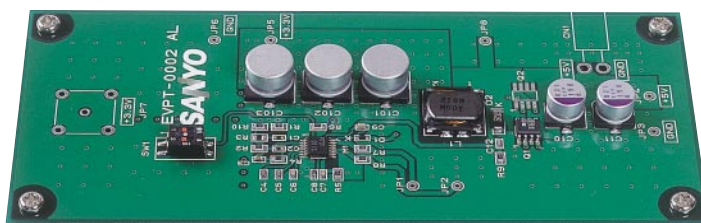
We can downsize by using the OS-CON compared with aluminum electrolytic capacitors if the most favorable phase compensating circuit is provided as follows.

Photo 1 Evaluated circuit boards

OS-CON



Aluminum electrolytic capacitor



4-4. Examples of design with aluminum electrolytic capacitors

When the aluminum electrolytic capacitors are used, the frequency characteristics of the output LC filter are as shown in Fig.6, and there is a sufficient phase margin to such an extent that there is no need to make phase compensation. Therefore, the phase compensating circuit in Fig.7 is sufficient.

Fig.6 Frequency characteristics of the LC filter with the AL-E

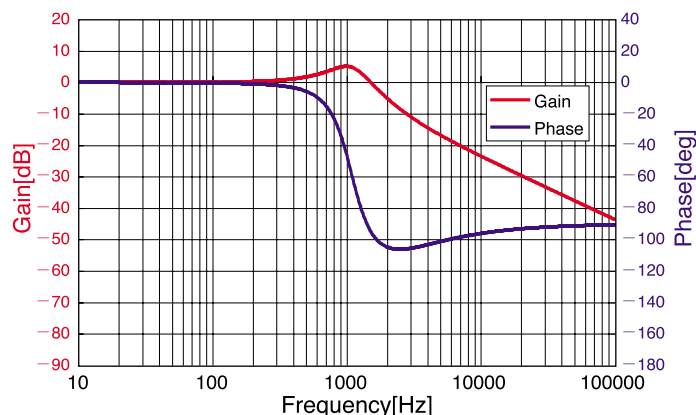
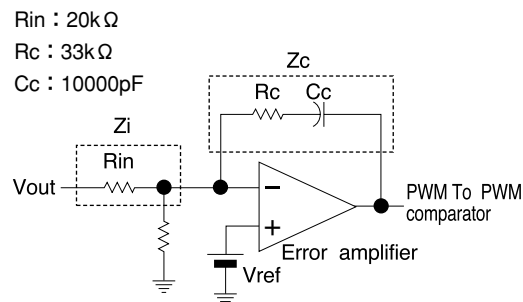


Fig.7 Phase compensating circuit with the AL-E



With the phase compensation network is Fig. 7 (properly speaking, phase compensation is not made), the total frequency characteristics are as shown in Fig. 8, and there is a sufficient phase margin.

Fig.8 Total frequency characteristics with the AL-E

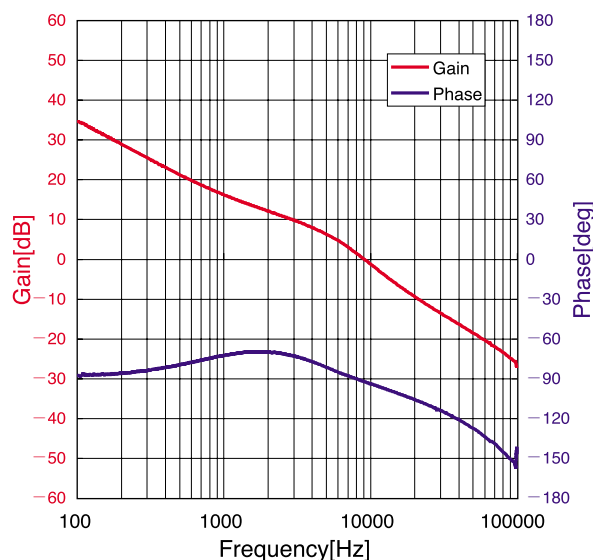
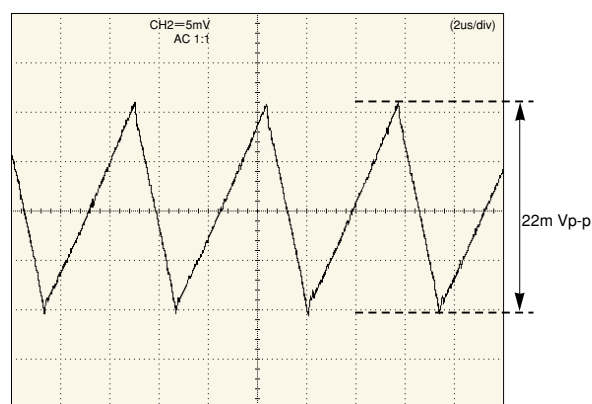


Fig.9 Output ripple voltage waveform with the AL-E

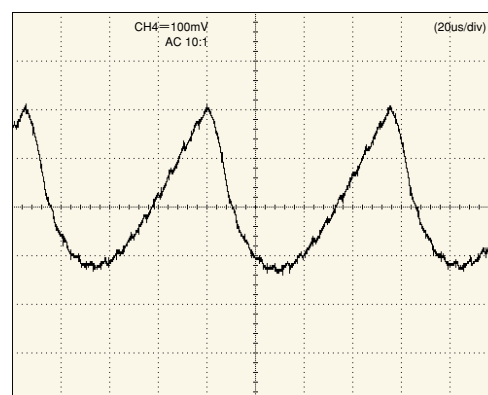


4-5. Examples of design with the OS-CON

When the aluminum electrolytic capacitors used in power supply circuits are replaced with the OS-CON without changing the phase compensation network, the output voltage oscillates. (Fig.10)

As a reason, we can say that the phase margin is lost because the phase compensation network is not changed despite the fact that the frequency characteristics of the output LC filter change as shown in Fig.6, where the aluminum electrolytic capacitors are used, to Fig.11, where they are replaced with the low ESR OS-CON.

Fig.10 Oscillating output voltage waveform



When the LC filter has little phase margin as shown in Fig.11, appropriate phase compensation can be made by using such a phase compensation network as shown in Fig.12.

This is to cancel the deepened phase lag by forming phase leads at Z_i and Z_c in Fig.12.

Fig.11 Frequency characteristics of the LC filter with the OS-CON

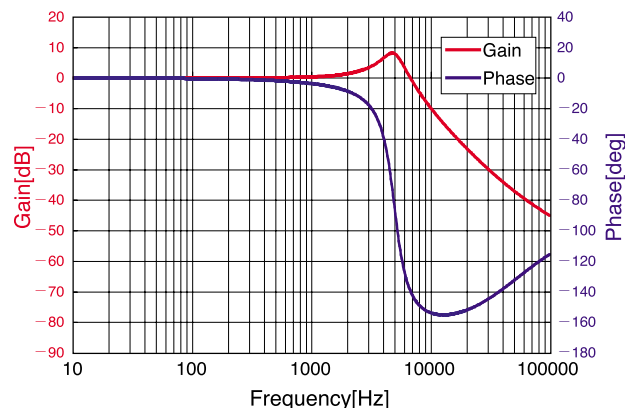
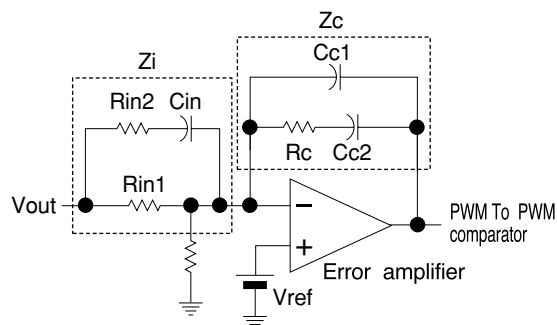


Fig.12 Phase compensating circuit with the OS-CON

Rin1 : 20k Ω Cin : 4700pF Cc1 : 330pF
Rin2 : 680 Ω Rc : 3.3k Ω Cc2 : 33000pF



Because of this, the total frequency characteristics are as shown in Fig.13; the phase margin is sufficient; and the output ripple voltage waveform (Fig.14) is almost the same as is the case with the aluminum electrolytic capacitors.

Fig.13 Total frequency characteristics with the OS-CON

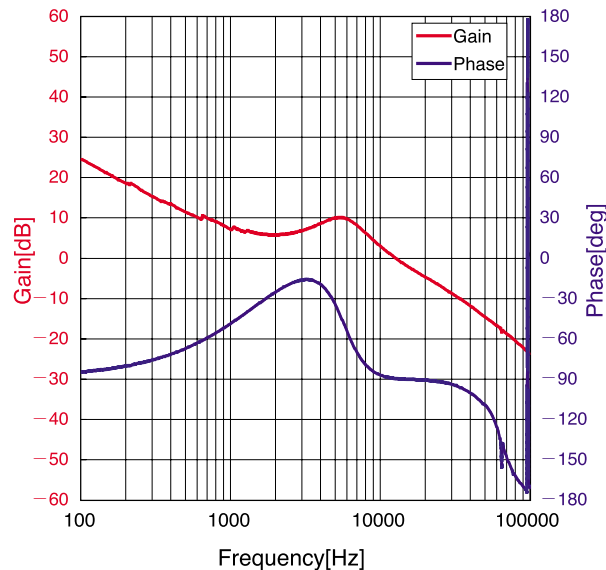
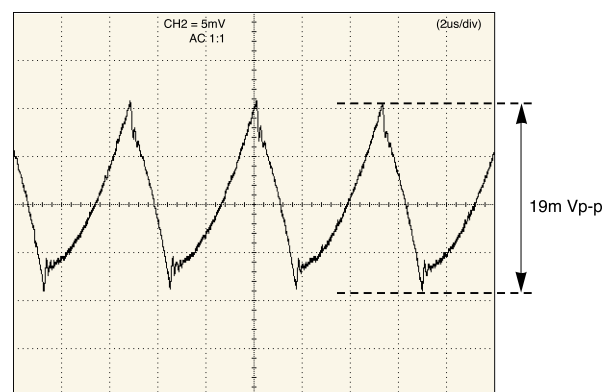


Fig.14 Output ripple voltage waveform with the OS-CON



5. Influence of output ripples from switching power supply on actual images

Comparison of the output ripple current among **OS-CON**, aluminum electrolytic capacitors and tantalum capacitors on P.72 to P.74. The result showed that the **OS-CON** provided an excellent filter effect, superior to those of other capacitors. This section discusses the influence of such ripples on images. You may understand how digital noise affects analog signals.

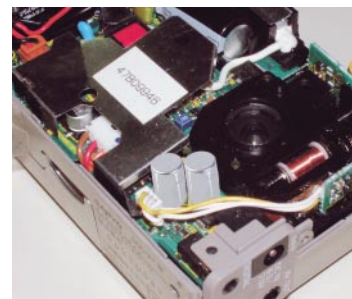
(a) Influence to images by a digital camera

OS-CON and low impedance aluminum electrolytic capacitors are connected respectively as output filter in DC-DC converter of a digital camera, and we compare the influences on actual images changing temperature.

Parts mounting circuit



OS-CON is used
10V/47 μ FX2P
size: ϕ 6.3×L5.0



Al-E is used
10V/330 μ FX2P
size: ϕ 6.3×L11.0

OS-CON ; SL series

Photo 1
at 25°C



Photo 3
at 0°C



Photo 5
at -20°C



Low impedance Aluminum electrolytic capacitor

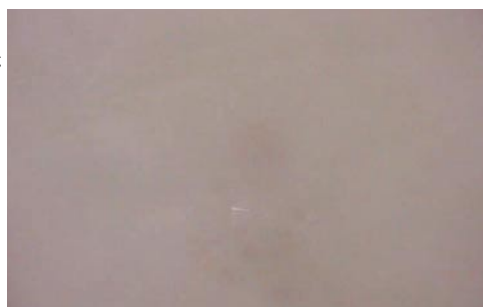
Photo 2
at 25°C



Photo 4
at 0°C



Photo 6
at -20°C



(b) Result

- (1) Images when use **OS-CON** : There were quite normal when the temperature is from 25°C to -20°C.
- (2) Images when use **low impedance aluminum electrolytic capacitors**: Images started to become white like misting around 0°C as a whole, and images hardly appeared at all at -20°C.

Company			
Dept.			
Name			
TEL		FAX	
E-mail			

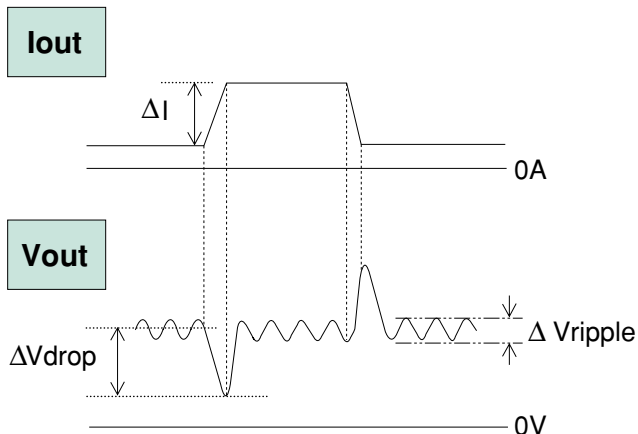
Application	Power Supply / Filter / By-pass Capacitor / Coupling Circuits / Others ()		
Equipment	PC / PC Peripheral Unit / Audio / Communication / Automobile / Other ()		
Height limit	mm	Mount type	Radial SMD

Indispensable item

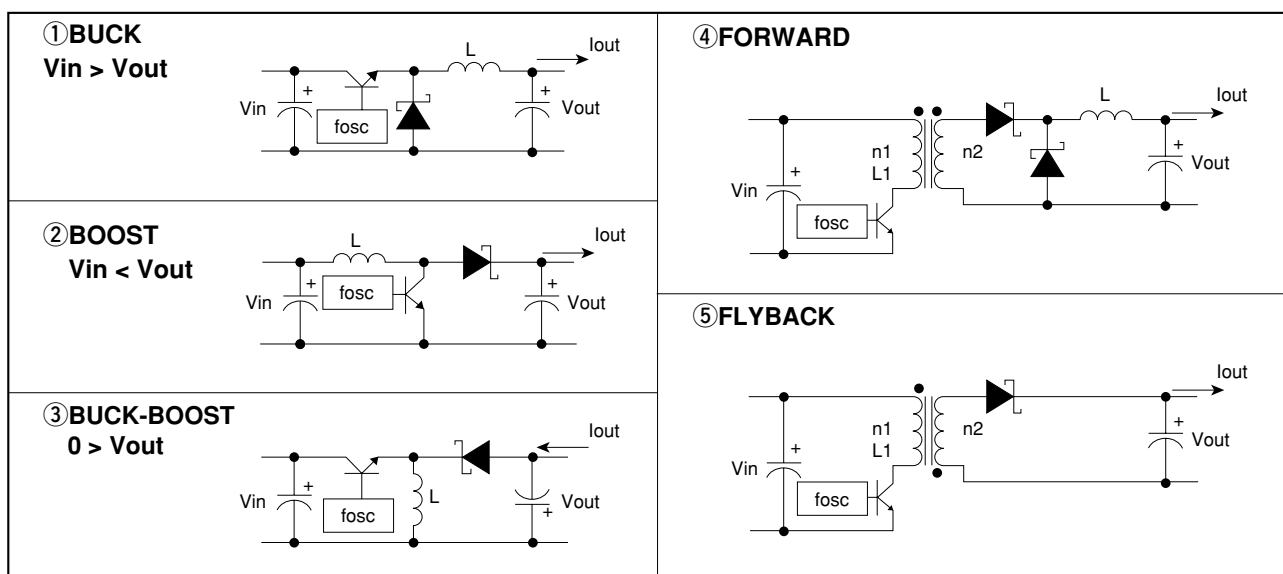
Item	Symbol	Value	Unit
Switching Frequency	fosc		kHz
Input Voltage	Vin		V
Output Voltage	Vout		V
Output Current	Iout		A
Ripple Voltage	ΔV_{ripple}		mVp-p
Ambient Temperature	Ta		°C
Primary Inductance	L1		μH
Inductance	L		μH
Winding ratio	n1 : n2	:	

Option

Current Change	ΔI		A
Voltage Drop	ΔV_{drop}		mV
Control IC			



◆Please enclose the use circuit in a circle.



The design support tool is available at the following URL on the Internet.
<http://www.sanyo.co.jp/compo/webcctool/jp/html/>



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Phone: (072)870-6375/6377 FAX: (072)870-1174 <http://www.edc.sanyo.com>

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