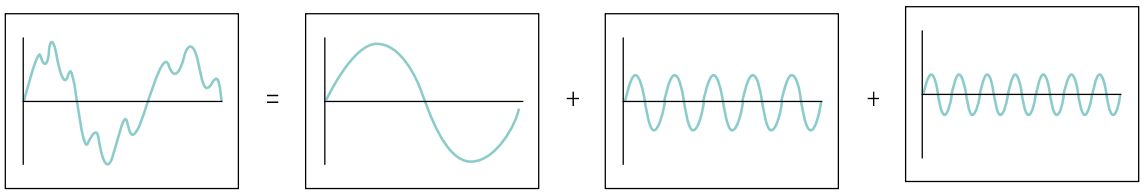
4. Special Capacitor

> Application

Due to rapid increase of devices using Tyristo the generator of harmonics recently, accidents and incidents in electricity
this product realized and became the cause of problems in the operation.
Therefore, the application of filter facilities is unavoidable to prevent the extension of harmonics in the system and prevent accidents by absorbing the harmonics and rationalize the use of electricity.

> What is harmonics?

Cyclic distortion wave is expressed as the sum of sine wave[50Hz], the integral number frequency and major sine wave, integral number[50Hz] frequency.
This integral number frequency is called harmonic wave and according to the change of amplitude and phase, wave form is changed resulting in synthetic distortion.
Combined distortion wave is manifested in distorted sine wave form. This form can be analyzed into one fundamental wave[50Hz] which has random cycle and major sine wave which has integral number frequency or subharmonic frequency. These sine wave less fundamental frequency are called harmonic and if the frequency of
it is higher than the fundamental frequency, it is called harmonics and if the frequency of it is lower, it is called fractional harmonic wave or subharmonic.
For example, an distorted wave form comprising sine wave type[50Hz]and 5th[250Hz] and 7th[350Hz] wave form is analyzed as following :



ex) Harmonics = Fundamental Wave + 5TH Harmonics Part + 7TH Harmonics Part

> Harmonics Generator

- Thyristior controller
- Speed controller
- Low speed starter
- Power factor compensator
- Rectifier
- Arc furnace
- Transformer, Reactor
- Transformer, Reactor
- Non-linear loads such as rotating devices changing the wave form of the current which generates harmonics.

> Process of Harmonic Filter Engineering

- Collecting data[system condition, harmonics spectrum, THD limit]
- Drawing system impedance map
- Calculating harmonics impedance and determining filtering order
- Harmonic flow calculation
- Simulation
- Checking abnormal resonance in the system and the possibility of harmonics extension
- Designing Switcher PNL, Structure
- Testing the operation after installation
- Test report

4-1 A.C. Harmonic Filter

> Disturbance by Harmonics

Harmonics generated in the system do not stay at the system, but go into the entire system of electricity and give fatal influence on other electric facilities.

- Overheating and loss of transformer
- Influx of over current of capacitor and noise
- Instability of control system
- Voltage change
- Overload of rotator
- Errors on the movement of circuit breaker
- Impediment in communication and interfering OA functions
- Heavy current in neutral and low voltage between phase and earthing

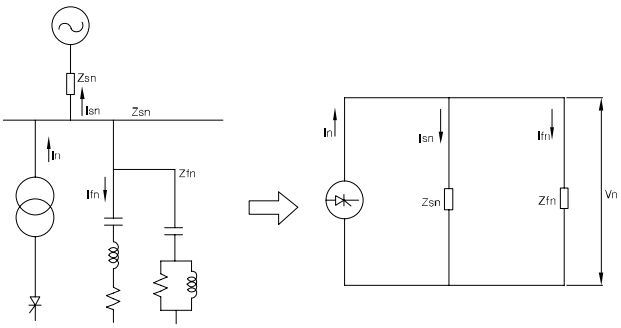
> What is Harmonic Filter?

Harmonic filter is a device which represses and absorbs the outflow of harmonics generated in the electricity system. It consists of resistor, reactor and capacitor.
Basic harmonic filter consists of lower order[5-13th order]single shunt filter which is synchronized with the harmonics current generated.
For other higher order frequency, higher order filter shall be installed, if necessary.

> Effects of Harmonic Filter

- Improvement of power factor[invalid power in the electricity system is removed, resulting in the improvement of economics]
- Absorption and removal of harmonics
- Resolving the problem of resonance between inductive and capacitive in the system.
- Keeping the performance and lifetime of the facility high by keeping normal voltage

The effects of contained harmonics current by filter can be expressed as following :



$$Vn = \frac{Zfn \cdot Zsn}{Zfn + Zsn} \cdot In = \frac{In}{Yfn + Ysn}$$

$$Vn = \frac{Zfn}{Zfn + Zsn} \cdot In = \frac{Ysn}{Yfn + Ysn} \cdot In\,, \quad Ifn = \frac{Zsn}{Zfn + Zsn} \cdot In = \frac{Ysn}{Yfn + Ysn} \cdot In$$

4-1 A.C. Harmonic Filter

> Current Distortion Limits for General Distribution Systems [IEEE Std 519-199]

Maximum Harmonic Current Distortion in Percent of I_L
Individual Harmonic Order [Odd Harmonics]

I_{SC} / I_L	〈11	11≤h〈17	17≤h〈23	23≤h〈35	35≤h	TDD
〈20*	4	2	1.5	0.6	0.3	5
20〈50	7	3.5	2.5	1	0.5	8
50〈100	10	4.5	4	1.5	0.7	12
100〈1000	12	5.5	5	2	1	15
〉1000	15	7	6	2.5	1.4	20

Even harmonics are limited to 25% of the odd harmonic limits above
Current distortions that result in a dc offset, e.g., half wave converters are not allowed.
'* All power generation equipment is limited to these values of current distortion regardless of actual Isc/I_L where
Isc = maximum short circuit current at PCC
I_L = maximum demand load current [fundamental frequency component] at PCC

> Voltage Distortion Limits [IEEE Std 519-1992]

Bus Voltage at PCC	Individual voltage Distortion[%]	Total Voltage Distortion THD[%]
69kV and below	3.0	5.0
69.001kV through and 161kV	1.5	2.5
161.001kV and above	1.0	1.5

4-2 Low Frequnecy Induction Furnace Capacitor

> Application.

This product was developed in 1977 with the purpose of rationalizing power supply by improving heat efficiency and power factor of Low Frequency Induction Furnace. This product consists of polypropylene film, aluminum thin film or metalized film which has excellent voltage resistance.
It contains specially produced composite oil, resulting in high reliability.

> Product Scope

- Installation Place : Indoor
- Ambient Temperature for use : -20℃ ~ +40℃ [below 35℃ average for 24hours]

> Technical Data

Tolerance on capacitance	-5 ~ +15% [at 20℃]
Withstand Voltage	10 seconds of 2.0 times of rated voltage between mutual terminals
Insulation Level	$2U_N$ + 2kV or 3kV, whichever is the higher, for 10 s
Max Overvoltage	Less than 105% of rated voltage : within 12hours per day
Max overcurrent	120% of rated capacity [less than 60Hz], 115% of rated capacity [more than 60Hz] or less
Capacitor Loss [Under stabilized condition]	0.35% [rated voltage, 20℃] or less

> Diagram

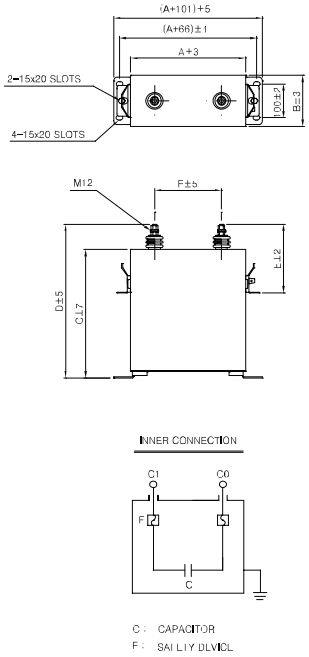


Figure 1

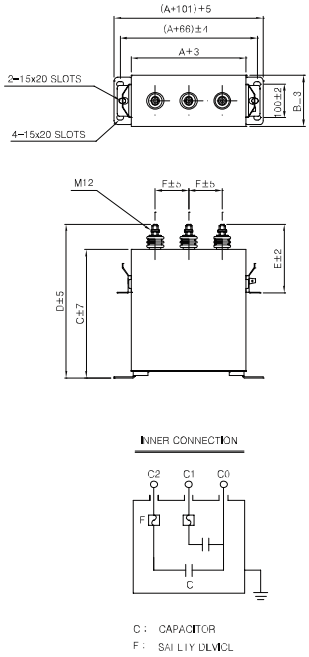


Figure 2

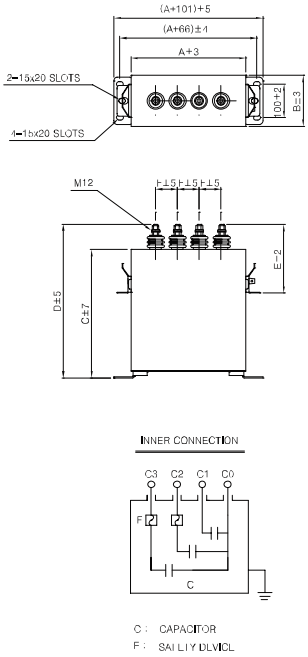


Figure 3

4-2 Low Frequnecy Induction Furnace Capacitor

> Ratings and Dimensions

Capacity	Votage [V]	Phase	Frequency [Hz]	Rated Capacity [kvar]	Type	Dimension [mm]						Figure
						A	B	C	D	E	F	
50	630	1	60	50	SMFL-66050 KS	343	153	280	355	205	200	1
100	440	1	60	11.1+22.2+66.7	SMFL-46100 KS	343	153	390	465	205	65	3
	600	1	60	50+50	SMFL-66100 KS	630	135	380	455	205	100	2
	630	1	60	100	SMFL-66100 KS	343	153	380	455	205	200	1
	800	1	60	100	SMFL-86100 KS	343	153	470	545	205	200	1
150	600	1	60	50+100	SMFL-66150 KS	630	135	500	575	205	100	2
	800	1	60	150	SMFL-86150 KS	343	153	640	715	295	200	1
200	600	1	60	200	SMFL-66200 KS	343	153	660	735	255	200	1
	750	1	60	25+40+135	SMFL-76200 KS	343	153	580	655	255	65	3
	1000	1	60	30+60+110	TAFL-106200 KS	343	153	840	915	295	65	3
	1000	1	60	100+100	TAFL-106200 KS	530	135	610	685	295	100	2
	1200	1	60	25+25+150	TAFL-126200 KS	530	170	480	555	205	65	3
	1200	1	60	50+50+100	TAFL-126200 KS	530	170	480	555	205	65	3

* Approximate Dimensions and ratings are given above. Please contact factory to check it before order.

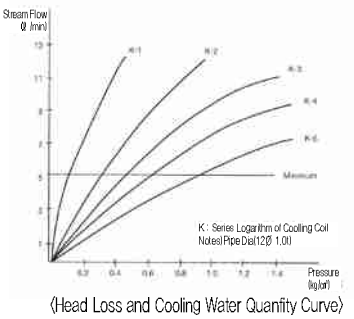
4-3 Water Cooling Capacitor

> Application

This product is specially designed to accommodate high capacity to be easily used for matching circuit of high frequency induction furnace device.
For dielectric, polypropylene film and capacitor paper was used together and aluminium foil electrode of non induction method was used. For insulating oil,
non PCB dielectric was impregnation resulting in stable and excellent feature.
For cooling method, it was designed that cooling water can absorb the heat generated from the inner dielectric loss.
To make matching circuit easily when inductive load is changed, capacity was divided into proper capacity and lead bushing was treated.
The material of case is non magnetic aluminum to minimize induction loss due to high frequency electric filed. The loss of capacitor itself is about 0.1%.
Maximum Water temperature rise should not exceed 4deg[5l/min], on the standard of maxim capacitance.
Permissible load power is 1.05 times of rated voltage [within1 hour per day]
and maximum permissible current is 1.35 times of rated current.
High frequency water cooling capacitor does not contain discharging resistor since it is connected to high capacity coil circuit in paralleled.
When capacitor is input into circuit again, the permissible limit of residual voltage should be within 10% of rated voltage and nuts with DC voltage.
Tightening strength on nuts at terminal is 200kg · ㎝ or less.

> Technical data

Installation place	Only for Indoor
Temperature of Cooling Water	Cooling water exit temperature less than 45℃
Ambient Temperature	More than 0℃
Tolerance	Within ± 10% of rated capacity
Withstand Voltage	2.15 times of rated voltage, 10 seconds
Flux of Cooling Water	More than 5ℓ per minute
Pressure of Cooling Water	Less than 10kg/㎠
Safety Device	Thermostat contact capacity [250VAC, 7.5A]
Case	Aluminium non painted product



〈Head Loss and Cooling Water Quantity Curve〉

> Caution

Since the outer case of capacitor is unilateral electrode, please be sure to use the insulated rack in installation.
When more than 2 capacitors are connected in paralleled, there should be space at least 35mm.
The flow quantity of cooling water shall be more than 5ℓ /min.
In case when capacitor is kept at subzero temperature, remove the water entirely from copper pipe

4-3 Water Cooling Capacitor

> Diagram

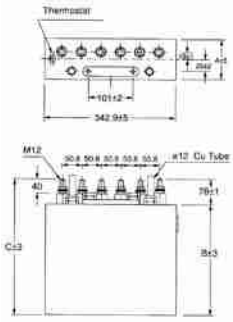


Figure 1

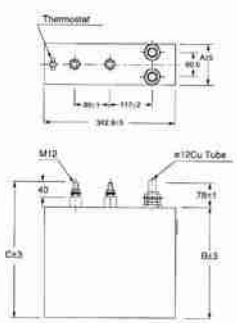


Figure 2

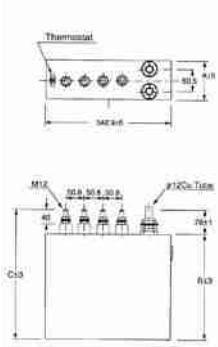


Figure 3

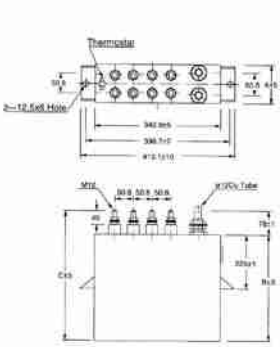


Figure 4

> Ratings and Dimensions

Frequency [Hz]	Rated Votage [VAC]	Rated Capacity [kvar]	Total [μF]	μF Per Section								Dimension [mm]			Figure
				1	2	3	4	5	6	7	8	A	B	C	
960	800	450	117	5	8	16	44	44	–	–	–	136.7	330.2	398.2	1
960	1000	480	80	13	13	27	27	–	–	–	–	104.6	330.2	398.2	3
1000	1250	750	76	3	3	3	3	13	13	19	19	104.6	360.2	428.0	4
1200	1250	1200	102	–	–	17	17	17	17	17	17	104.6	330.2	398.2	
2000	1250	300	15	7.6	7.6	–	–	–	–	–	–	136.7	200.0	368.0	2
3000	400	300	100	7	13	27	53	–	–	–	–	104.6	200.0	268.0	3
3000	800	1000	84	21	21	21	21	–	–	–	–	104.6	330.2	398.2	
3000	1250	1200	40	3	3	3	3	7	7	7	7	104.6	330.2	398.2	4
3000	1250	1200	40	2	2	2	2	6	10	10	10	104.6	330.2	398.2	

* Approximate Dimensions and ratings are given above. Please contact factory to check it before order.

4-4 Surge Absorbing Capacitor

> Application

This product was developed by our company in 1976 to absorb and reduce surge which may be generated when the breaker is open or closed and lighting surge by connecting transmission line and, closed and lightning surge which may be delivered by connecting transmission line and ground.
Its dielectric is polypropylene film which has excellent withstand voltage and good quality capacitor paper and it also contains specially produced composite oil.
The Capacitor with series resistance was developed to improve electric feature.

> Product Scope

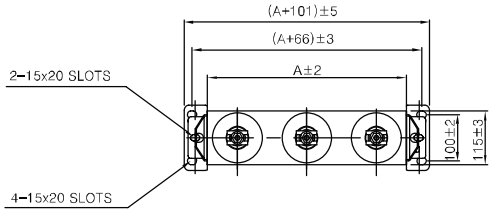
- Installation Place : Both indoor and outdoor
- Ambient Temperature : -20℃ ~ +40℃ [below average 35℃ per day, below 25℃ average per year]

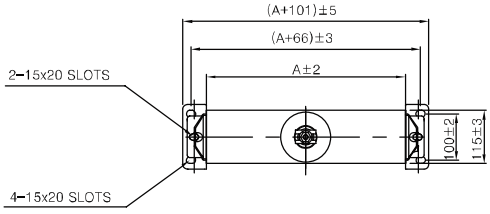
> Technical Data

Tolerance	-5% ~ +15%[at 20℃], less than 108% of unbalanced ratio between phases
Max overvoltage	Below 110% of rated voltage : within 8hours per day Below 115% of rated voltage : within 30minutes per day Below 120% of rated voltage [less than 2times of 5min. per month] Below 130% of rated voltage [less than 2times of 1min. per month]
Max overcurrent	Transient current 130% of rated current allowed
Withstand Voltage	Between case and all of terminals
Capacitor Loss [Under stabilized condition]	Less than 0.5% [at rated voltage, 20℃], in case C-R type less than 0.6%
Reference Standard	JEM1362[1999]

Line voltage	Test voltage	
3300V	16kVAC[1min.]	45kVDC[10sec.]
6600V	22kVAC[1min.]	60kVDC[10sec.]
11000V	28kVAC[1min.]	90kVDC[10sec.]
22000V	50kVAC[1min.]	150kVDC[10sec.]

> Diagram





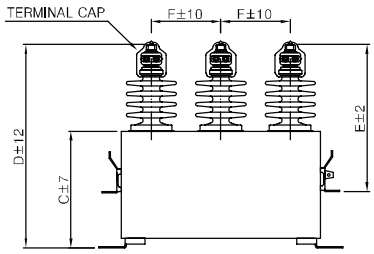


Figure 1

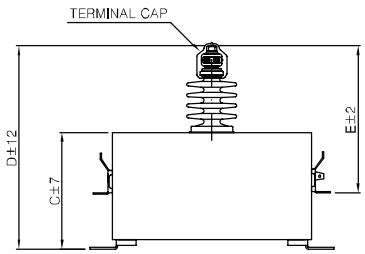


Figure 2

4-4 Surge Absorbing Capacitor

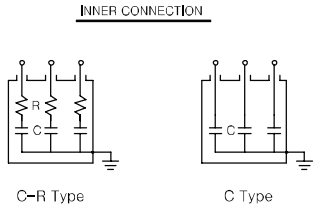


Figure 1

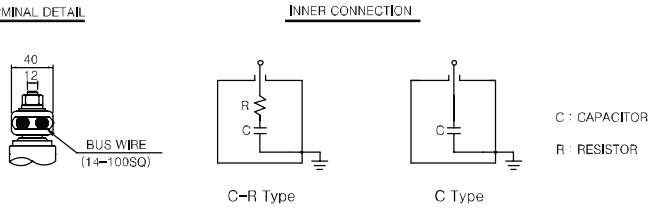
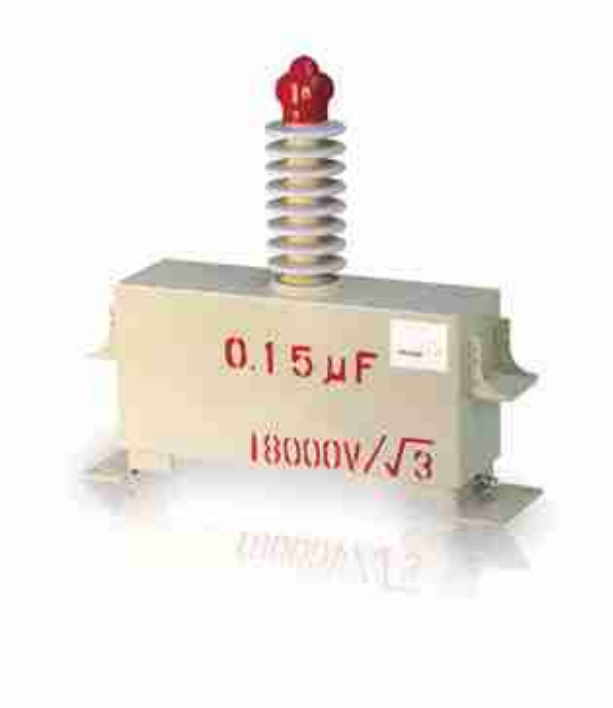


Figure 2

› Ratings and Dimensions

Rated Votage [VAC]	Rated Capacity [kvar]	Type	Dimension [mm]						Figure
			A	B	C	D	E	F	
3300/√3	0.05 μF x 3	THF-T30015T[CR]	430	115	250	435	315	150	1
3300/√3	0.1 μF x 3	THF-T3003T[CR]	430	115	220	435	315	150	
3300/√3	0.5 μF x 3	THF-T305T	430	115	270	455	315	150	
3300/√3	0.8 μF x 3	THF-T3024T	430	115	270	455	315	150	
6600/√3	0.05 μF x 3	THF-T60015T[CR]	430	115	250	435	315	150	
6600/√3	0.1 μF x 3	THF-T6003T[CR]	430	115	250	435	315	150	
22900/√3	0.1 μF	THF-T23001SCR	430	145	250	520	400	-	2
13800/√3	0.3 μF	THF-T13003S	430	145	280	510	360	-	
24000/√3	0.2 μF	THF-T24002S	430	145	350	620	400	-	
24000/√3	0.4 μF	THF-T24004S	530	135	450	720	400	-	

* Approximate Ratings and Dimensions are given above. Please contact factory before order.



4-4 Surge Absorbing Capacitor

> Operation principle

To explain the effect of surge absorbing capacitor, the rotator is expressed as intensive equivalent resistance R as in the figure A.
In parallel with this, on the circuit to which the protecting Capcitor is connected,
VO = EOH[t] travelling wave invaded from line of surge impedance Z.
Then, when terminal voltage of R and C is Vc, the current Ip at P point is

$$Ip = C\frac{dVc}{dt} + \frac{1}{R}Vc = \frac{1}{Z}[2Vo - Vo]$$

To rearrange the expression $\frac{d}{dt} = P$, Vo = EoH[t]

$$PVc = \frac{R+Z}{CRZ}Vc = \frac{2Eo}{CZ}H[t]$$

$\left(\frac{R+Z}{CRZ}\right) = \alpha$ it B = a

$$Vc = \frac{2Eo}{CZ} \times \frac{1}{P+\alpha}H[t] = \frac{2Eo}{\alpha CZ}[1-e^{-\alpha t}]H[t]$$

When Z and R is constant and C is changed, the terminal voltage of the rotator Vc is as in the figure B. From this, it can be seen that the wave height value is reduced according to the value of C or R. When R = ∞ and C = 0.3μF, the terminal voltage of the rotator is reduced to 1/2 of invasion wave, which shows the effects of surge absorbing capcitor.

Figure A

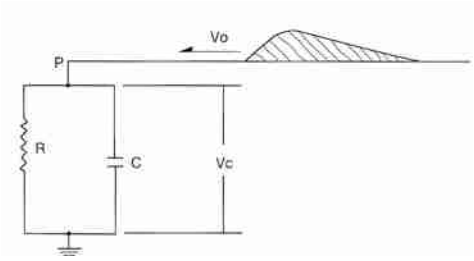
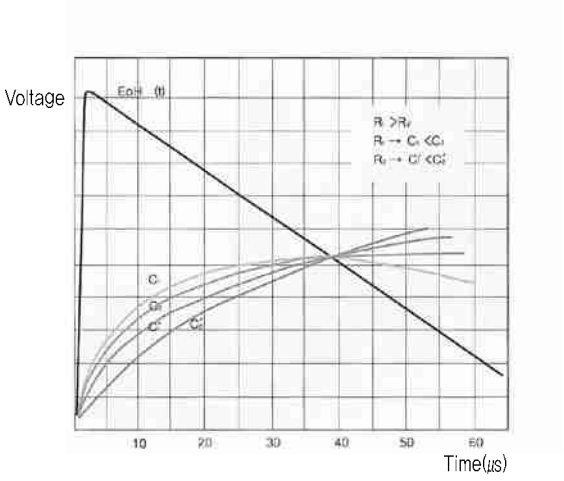


Figure B



4-5 Grounding Capacitor

> Application

This porduct was developed by our company in 1975 to improve capacity between distribution line and earth by connecting the 2nd
winding distribution line of insulation transformer and earth. It uses polypropylene film which has excellent insulation ability
and good quality capacitor paper as dielectric and contains specially produced composite oil to improve electric feature.

> Product Scope

- Installation Place : Both Indoor and Outdoor
- Ambient Temperature : -20℃~+40℃[below 35℃ average per day, below 25℃ average per year]

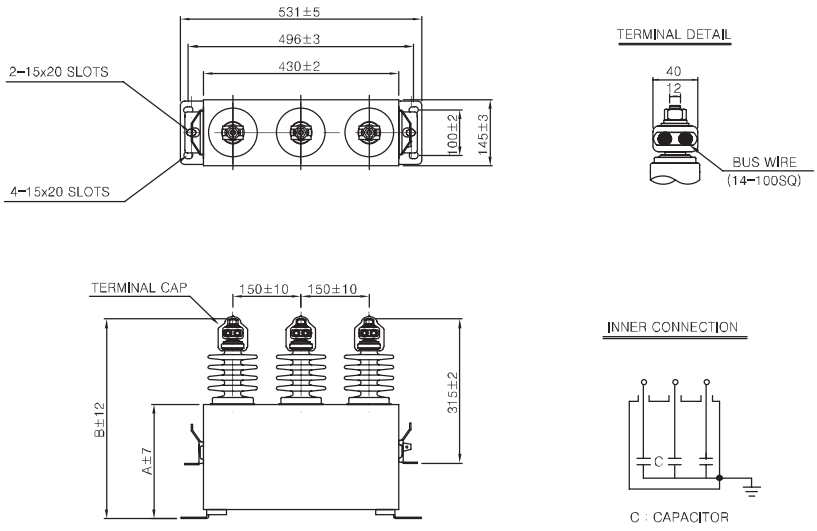
> Technical Data

Tolerance	-5% +15%[at 20℃], less than 108% of unbalanced ratio between phases
Max overvoltage	Below 110% of rated voltage : within 12hours per day
	Below 115% of rated voltage : within 30minutes per day
	Below 120% of rated voltage : within 5minutes
	Below 130% of rated voltage : within 1minute
	Below 182% of rated voltage : within 2 seconds
Max overcurrent	Transient current 130% of rated current allowed
Withstand Voltage	Between case and all of terminals

Line voltage	Test voltage	
3300V	10kVAC[1min.]	30kVDC[10sec.]
6600V	16kVAC[1min.]	45kVDC[10sec.]

Capacitor Loss	Less than 0.35% [at rated voltage, 20℃]
Painting Color	Munsell no. 5Y 7/1
Reference Standard	JEM1362[1999]

> Diagram



4-5 Grounding Capacitor

> Ratings and Dimensions

Line Voltage [V]	Rated Capacity [kvar]	Type	Dimension[mm]	
			A	B
3300	10	TBF-T36010Y	490	675
6600	10	TBFT66010Y	290	475

* Approximate Dimensions are give above. Please contact factory for exact deimensions of a particular capacitor

> Operation Principle

In 3 phase circuit, for 1 line grounding current is calculated from the following formula.

$$Ig = 3j\omega CEa = j\ E\times 2\pi fC$$

Ig : Grounding Current[A] E : Line Voltage [V]

Ea : Phase Voltage [V] C : Equivalent Ground Capacitance [$C = C_1 + C_2$]

I_{C1} [Ground fault current Ig in figure A – charged current after zero phase current transformer [ZCT]] passes the zero phase current transformer. Therefore, ground fault current I_{g1} passing ZCT can be calculated from the following formula.

$$Ig = \sqrt{3}E\times 2\pi\times f\times C_1$$

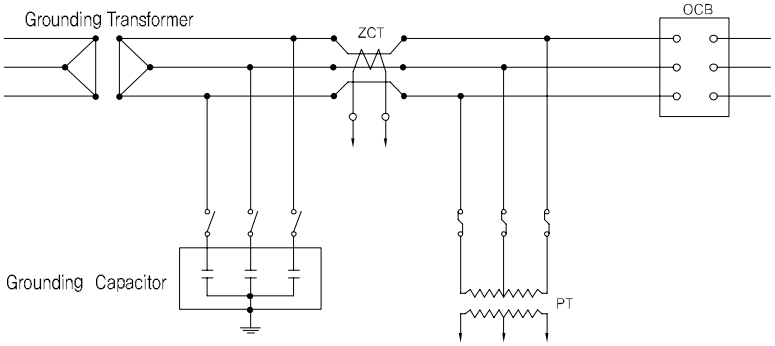
When the distance between transformer and ZCT is small, ground capacity in line is small and penetration ground fault current I_{g1} is not enough to move circuit breaker. Therefore, use capacitor for earthing to improve ground capacity in line.

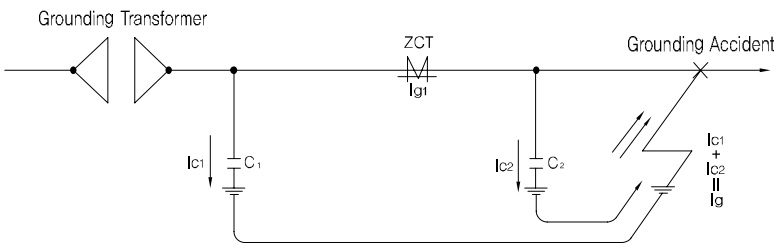
For example, when E=3300V, C_1=0.5μF, and f=50Hz in figure B, ZCT penetration ground fault current is as following :

$$I_{g1} = \sqrt{3}\times 3300\times 2\pi\times 60\times 0.5\times 10^{-6} = 1.08[A]$$

Since detecting current of grounding breaker is selected to be 0.1 ~ 0.8A, it is good to select the value of C_1 to be more than this value

[C_1 is equivalent to 1 phase and in case of C_1= 0.5μF, capacitor for grounding of 0.5μF×3 is to be selected]





4-6 Pulse Power Capacitor

> Application

It is normally used in the area of power supply device for tests,for example IVG, ICG, Mark Generator, Power Supply for L-C resonance circuit and small scale power supply for fusion study] and Power supply pulse power[state of art medical instruments, rock destruction and pulse laser] and recently, households which use this capacitor have been rapidly increased.
Since high energy density capacitor for pulse power is the key part of aircrafts [fighter, artificial satellite and passenger airplane],electronic / electric heat chemical gun, high efficiency laser and high efficiency munitions such as radar, the supply of this product was difficult since the industrialized countries regulated the outflow of technology. But, recently our company mass porduced the capacitor resulting in smooth supply of the product. In 1997, 11kVDC 150μF 9kJ rated capacitor for energy storage was developed with our own technology and delivered them for power supply of simple composite test facility and its performance has been recognized.
Several capacitors were also installed at heavy electro mechanics manufacturers in Korea and are used for test facilities.

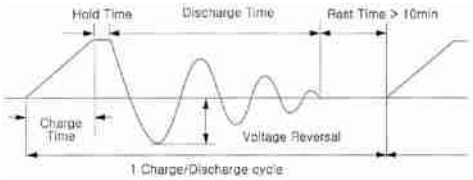


Figure 1

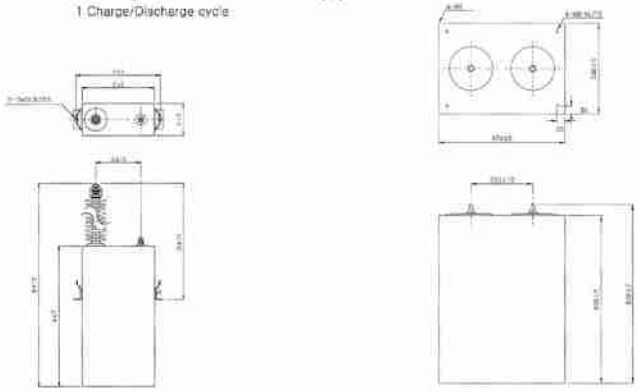


Figure 2

> PulsePower Low Capacitor

This product uses polypropylene film which has excellent withstand voltage and good quality capacitor paper as dielectric and contains refined impregnation oil, resulting in high reliability. To minimize inner inductance, it employs non inductive solder for reducing self inductance.

- Installation Place : Indoor
- Ambient Temperature : −10℃ ~ +40℃ [Average 35℃ or less per day]
- Technical Data

Tolerance	−10% ~ +10%[at 20℃]
Insulation Resistance	More than 1000MΩ between batch terminal and case [below20℃]
Withstand Voltage	Rated voltage × 1.2times, for 60 seconds between terminal and case
Painting Color	Munsell no. 5Y 7/1
Self Inductance	Max. 150nH
Duty Cycle	Pause for more than 10 min. per charging / discharging
Voltage Reversal	20% ~ 90%

4-6 Pulse Power Capacitor

> Ratings and Dimensions

Rated Votage [VADC]	Capacity [uF]	Joule [kJ]	Type	Dimension [mm]							Weight [kg]	Figure	Remarks
				A	B	C	D	E	F	F			
11	150	9.08	TFT-T11150S	810	995	160	315	370	424	228	70.7	1	Steel Case
40	0.01	0.01	TFT-T40001S	190	375	115	315	430	496	300	20.8		
	11	8.80	TFT-T40011S	560	745	170	530	530	583	300	71.8		
100	0.5	2.50	TFT-T100001S	390	660	135	530	530	583	380	42.6		
	1.0	5.00	TFT-T100001S	690	690	135	530	530	583	380	73.4		
25	0.3	0.09	TAE-25001S	-	-	-	-	-	-	-	6.7	2	Plastic Case
100	0.1	0.50	THE-100001S	-	-	-	-	-	-	-	7.5		

* Approximate Ratings and Dimensions are given above. Please contact factory before order.

> High Energy Density Pulse Power Capacitor

With metalized polypropylene film made through metalized technology and good quality capacitor paper as dielectric, this product realized high energy density, high reliability and long life span.

- Installation Place : Indoor
- Ambient Temperature for Use : -10℃ ~ +40℃ [below 35℃ average per day]
- Techinical Data

Tolerance	-10% ~ +10%[at 20℃]
Insulation Resistance	More than 1000MΩ between batch terminal and case [below20℃]
Withstand Voltage	Rated voltage × 1.2times, for 60 seconds between terminal and case
Painting Color	Munsell no. 5Y 7/1
Self Inductance	Max. 150nH
Duty Cycle	Pause for more than 10 min. per charging / discharging
Voltage Reversal	20% ~ 90%

> Ratings and Dimension

Rated Votage [VADC]	Capacity [uF]	Energy Density[kJ/kg]	Type	Dimension [mm]			Weight [kg]	Figure
				A	B	C		
20	200	0.33	SDF-T20200S	620	660	340	120	2

> Basic Information for Order

- Capacity and tolerance on capacitance
- Charging time and hold time
- Rated voltage and voltage reversal [%]
- Maximum current [kA] in discharging and discharge time
- Required life span and 1 time charging / discharging cycle