DEKI CAPACITOR GUIDE

Fan Regulators

A series on topics of relevance and advances from the Technical Centre, Deki Electronics Ltd, India *February 2012*

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DEKI CAPACITOR GUIDE
Fan Regulators

FAN REGULATOR
A Fan Regulator, as the name suggests, regulates or controls the speed of the fan motor. Before dealing with the fan regulator, a brief discussion about the fan motor is necessary, as the main purpose of the regulator is to control the speed of the fan motor.

FAN MOTOR
The motor used in a household ceiling fan is a 1φ squirrel cage type induction motor with the properties and specifications of a normal 1φ motor.

CONSTRUCTIONAL FEATURES
A 1φ induction motor employs two windings for its operation as it is not a self-starting version of an induction motor (polyphase motor). The two windings are main/running winding and starting/auxiliary winding. The windings are placed on a stationary member called stator, that has stampings and slots to hold the windings.

The rotor is the rotating member, of a squirrel cage type, on which the fan blades are mounted.

Note: It also incorporates a capacitor in series with a starting winding.

PRINCIPLE OF OPERATION
A ceiling fan motor is based on Faraday's Law of Electro-magnetic Induction according to which whenever a conductor is placed in a rotating magnetic field, an electro-magnetic force (emf) is induced. The frequency of the induced emf is the same as the supply frequency and its magnitude is proportional to the relative motion between the flux and the conductor. The direction of the induced emf is given by Fleming's Right Hand Rule.

WORKING
In order to make a ceiling fan self-starting, a starting or auxiliary winding is used, placed electrically 90° apart from the main winding, with a running capacitor in series with the starting winding. Both the windings are connected in parallel to each other. Winding supply across the terminal as shown in the figure.

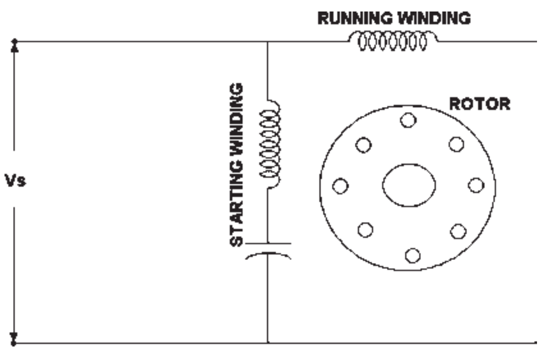


Fig: Capacitor Run Fan Motor

PURPOSE OF RUNNING CAPACITOR
A capacitor is incorporated in circuit so that I_S and I_M are 90° apart in phase from each other (ideal case) so that a revolving or rotating magnetizing flux can be set up.

STARTING OF FAN
When the supply is given a rotating flux is set up in the stator which is revolving with synchronous speed N_S.

$N_S = (120*f) / p$

f = supply frequency

p = number of poles

This flux induces a voltage in the rotor due to electromagnetic induction. As this rotor is initially stationary, torque is developed which rotates the rotor and rotor speed starts to build up. The direction of rotation is the same as that of the rotating flux. The torque developed is given by

$$T \propto S V^2$$

S = slip speed

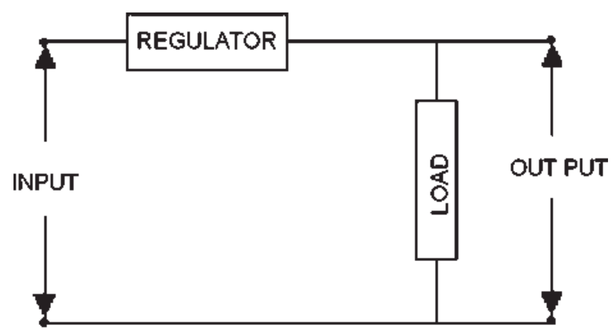
Now, this torque is proportional to square of voltage.

$$\text{Speed} \propto \text{Torque} \propto V^2$$

Hence, by controlling the voltage supply across the fan its speed can be varied.

TYPES OF FAN REGULATORS
Currently Fan Regulators are of these four types:
- Resistive regulator
- Phase angle controlled regulator
- Inductive regulator
- Capacitive regulator (latest).

RESISTIVE REGULATOR
This is the most common type in household ceiling fans. It works by providing different taps on a wire wound resistor connected in series with the fan.



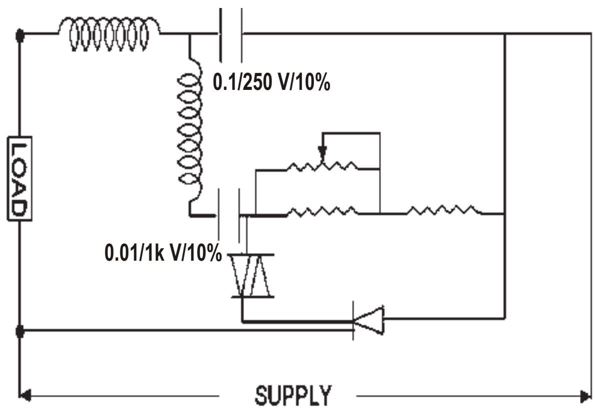
Advantages
- Cost-effective.

Disadvantages
- Considerable power loss as heat, especially at lower speeds, making it inefficient
- Bulky, lack of aesthetic appeal
- Very high energy consumption.

Fan Regulators

PHASE ANGLE CONTROLLED REGULATOR

Phase angle controlled regulators employ active devices such as DIAC and TRIAC. The basic principle is to change the firing angle of the TRIAC in order to change the voltage across the fan.



Advantages

- Continuous speed control
- Low power consumption as compared to resistive type regulators.

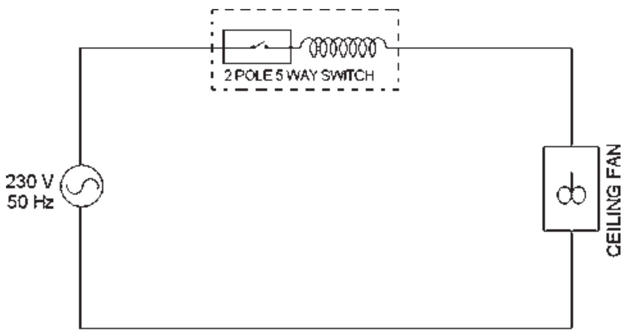
Disadvantages

- Speed control not linear
- Expensive as compared to resistive fan regulators.
- Produces humming sound that is disturbing
- Higher failure rate as active devices are susceptible to power supply transients and interference
- Causes EMI/RFI interference creating disturbances in TV and radio sets.

INDUCTIVE TYPE FAN REGULATOR

An inductive type fan regulator has a tapping on the winding of the transformer and the inductive reactance is varied to achieve variation in speed.

NOTE: Speed decreases with the increase in the number of turns of the inductance coil winding.



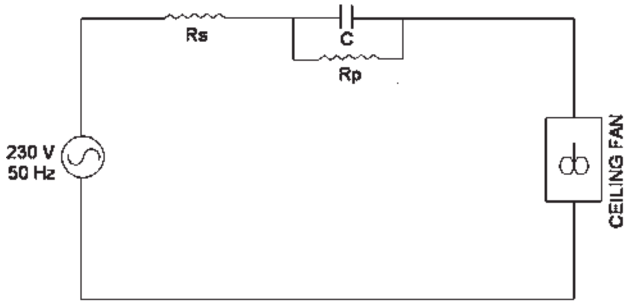
Advantages

- Low heat power dissipation.

Disadvantages

- Low power factor.
- Quite costly.
- Heavy and bulky.

CAPACITIVE TYPE FAN REGULATOR



Basic Principle

The main purpose here is to control the voltage acrossthe fan. As we know, the voltage across the capacitor is given by the formula $V_c = Q/C$ where Q is the charge across the capacitor and C is the capacitance.

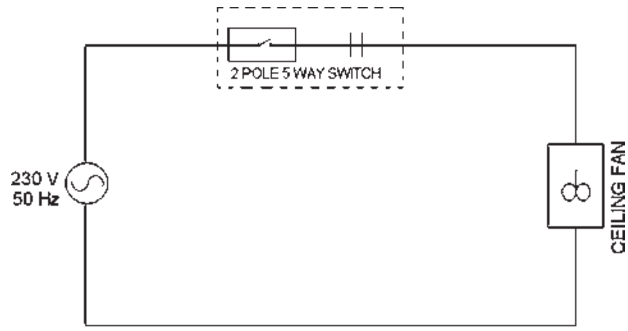
According to the formula above, $C \propto 1/V_c$.
As C increases V_c decreases. Thus, the voltage across the fan increases. Therefore, the speed increases. So, by increasing the value of capacitor, the speed of the fan can be increased. Thus, by employing suitable combinations of capacitors a fan's speed can be regulated.

Purpose of R_s and R_P

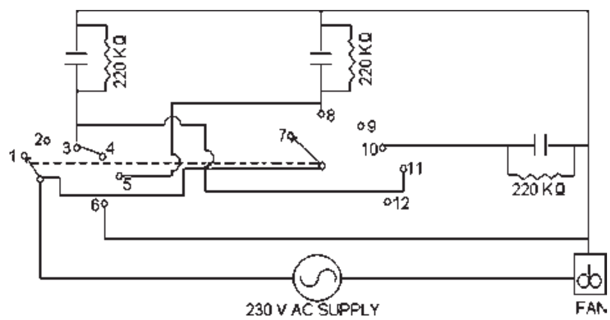
R_S is a series resistance which is used in series with the capacitor in order to limit the current flowing to the capacitor to a safe value.

R_P is a parallel resistance which serves as a discharging path for the capacitor for each supply cycle.

CAPACITIVE FAN REGULATOR - BLOCK DIAGRAM

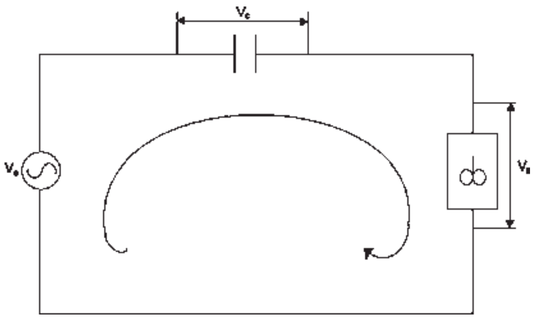


CAPACITIVE FAN REGULATOR - CIRCUIT DIAGRAM



Fan Regulators

How to calculate the value of the capacitors



Applying KVL (Kirchof's voltage law), the calculated value of X_C is given by $(V_S \times Z_F - V_F \times Z_F) / V_F = X_C$

where, V_S = supply voltage

V_F = voltage across the fan

Z_F = impedance of the fan,

and, the value of capacitance can be calculated by

$C = 1 / (2 \times \pi \times f \times X_C)$

where, f is the supply frequency.

Advantages

- Energy efficient
- No humming sound during operations
- Speed is linear
- High reliability as compared to electronic type regulator.

Disadvantages

- Becaues of size only marginal design is possible for film capacitor
- Fire hazard is, hence, the only failure mode.

Deki's technology breakthrough overcomes this problem. For more details please see page 16.

Let us examine the **ISI standards for fan regulators as per IS:374-1979:**

- Regulators including electronic type of speed regulators shall be capable of reducing the speed of the fan at least 50 per cent of the full speed at the test voltage.
- Fans shall be capable of running on all the running positions of the regulator at the rated voltage or within the whole rated voltage range.
- Shall have an 'OFF' position preferably next to the lowest speed contact.
- Shall be provided with not less than five running positions except in case of continuously variable speed regulators.
- The speed difference at any running position shall not deviate by more than +/- 50 % from the ideal speed difference calculated on the basis of maximum and minimum speeds divided by the number of steps.
  - Max speed of the fan: 400 rpm
  - Min speed of the fan: 200 rpm
  - Regulator steps: 5
  - Ideal speed difference = 200/5 = 40 rpm
- Speed difference between any two running positions
- should be between 20 and 60 rpm.
- Electronic type regulators shall be provided with radio
- and television interference suppressing devices.
- The voltage drop across the electronic type regulators at
- the maximum speed position shall not exceed 2% of the
- rated voltage of the fan.

EXPERIMENTAL STUDY

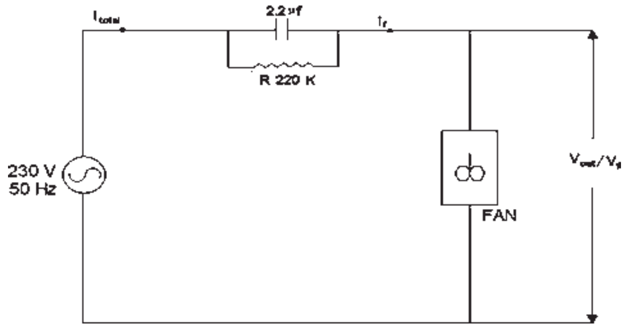
Fans from different manufacturers are tested on a standard regulator with combinations of 2.2, 1.0 and 3.1 µF.

Now,
At speed 1 = 2.2 µF
At speed 2 = 3.1 µF
At speed 3 = 4.1 µF
At speed 4 = 5.3 µF
At speed 5 = no capacitor

For,
Fan A, maximum RPM = 320
Fan B, maximum RPM = 422
Fan C, maximum RPM = 380

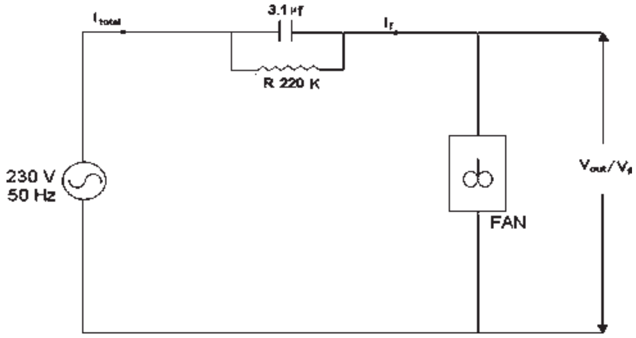
Configurations at various switch positions

Position 1



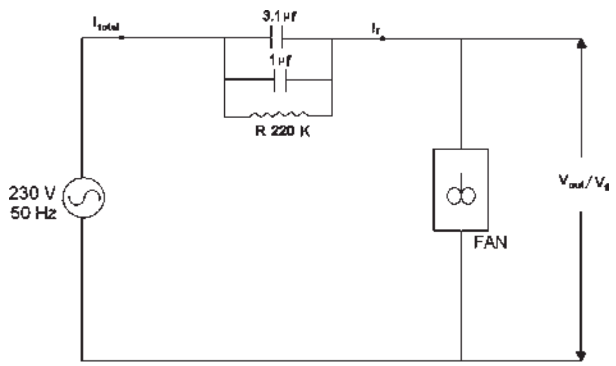
At this position, capacitor in the circuit = 2.2 µF.

Position 2



At this position, capacitor in the circuit = 3.1 µF.

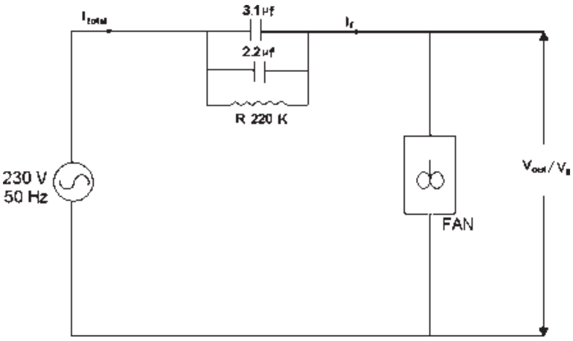
Position 3



At this position, capacitor in the circuit = 3.1 + 1 = 4.1 µF.

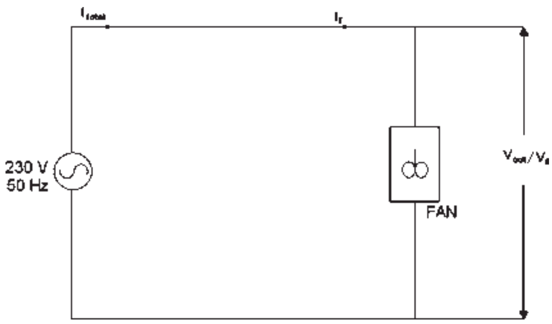
Fan Regulators

Position 4



At this position, capacitor in the circuit 3.1 + 2.2 = 5.3 µF.

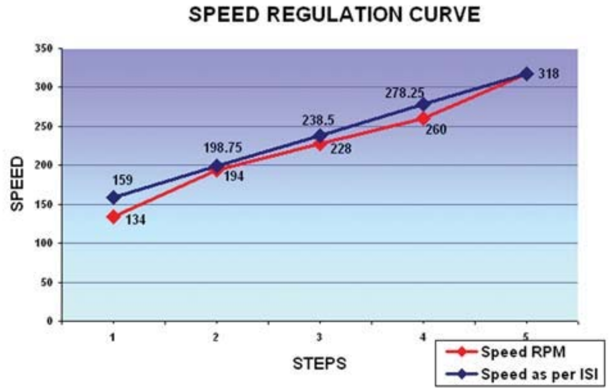
Position 5



At this position there is no capacitor in the circuit and the fan moves at the full rated speed.

Type A fan tested on a standard regulator
Case 2: Supply voltage = 230V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM	Speed Acc. ISI
1	83	0.110	9.13	208.000	134	159.00
2	116	0.160	18.56	190.200	194	198.75
3	137	0.190	26.03	171.200	228	238.50
4	155	0.220	34.10	150.000	260	278.25
5	230	0.260	59.80	0.222	318	318.00



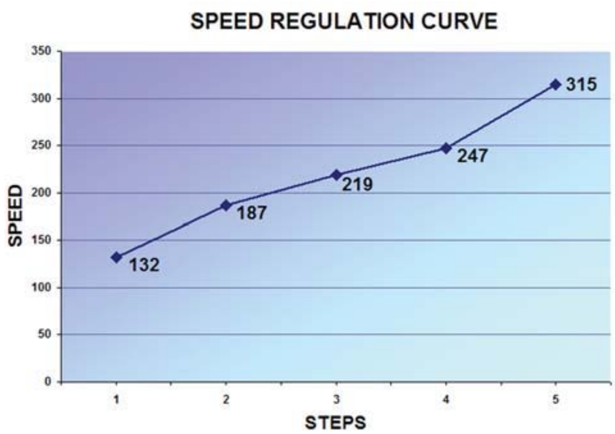
DATA SHEETS

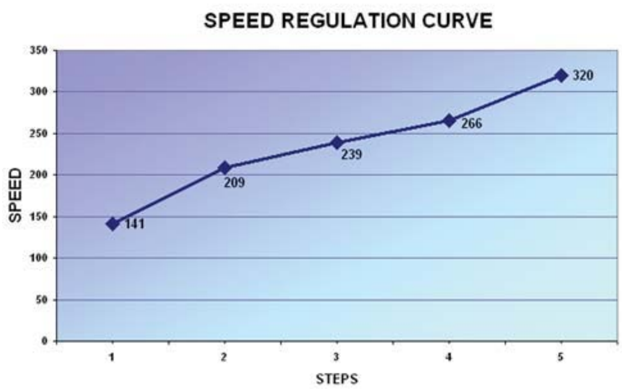
Type A fan tested on a standard regulator
Case 1: Supply voltage = 220V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	81	0.100	0.81	200.000	132
2	112	0.150	16.80	181.000	187
3	131	0.180	23.58	164.000	219
4	150	0.210	31.50	143.000	247
5	220	0.250	55.00	0.044	315

Type A fan tested on a standard regulator
Case 3: Supply voltage = 240V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	81	0.100	0.81	200.000	132
2	112	0.150	16.80	181.000	187
3	131	0.180	23.58	164.000	219
4	150	0.210	31.50	143.000	247
5	220	0.250	55.00	0.044	315

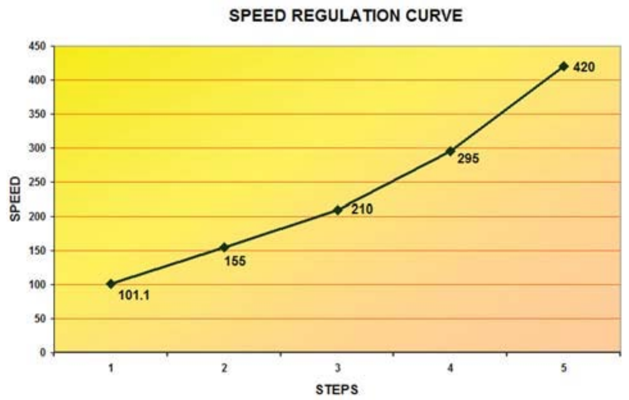




Fan Regulators

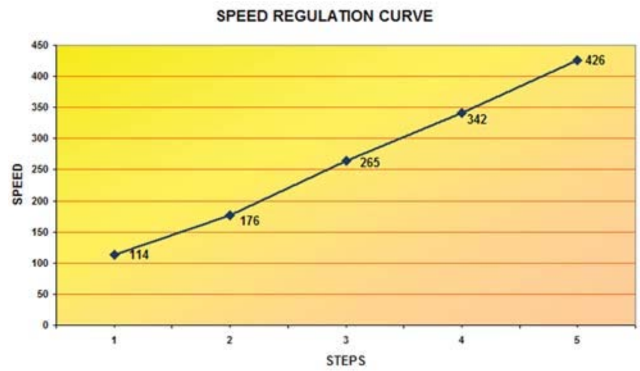
Type B fan tested on a standard regulator
Case 1: Supply voltage = 220V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	76	0.110	8.36	219.40	101.1
2	111	0.170	18.87	201.40	155.0
3	134	0.210	28.14	187.40	210.0
4	154	0.240	36.96	163.90	295.0
5	219	0.290	63.51	0.06	420.0



Type B fan tested on a standard regulator
Case 3: Supply voltage = 240V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	83	0.130	10.79	235.000	114
2	121	0.190	22.99	218.700	176
3	144	0.230	33.12	198.700	265
4	166	0.250	41.50	170.300	342
5	238	0.310	73.78	0.068	426

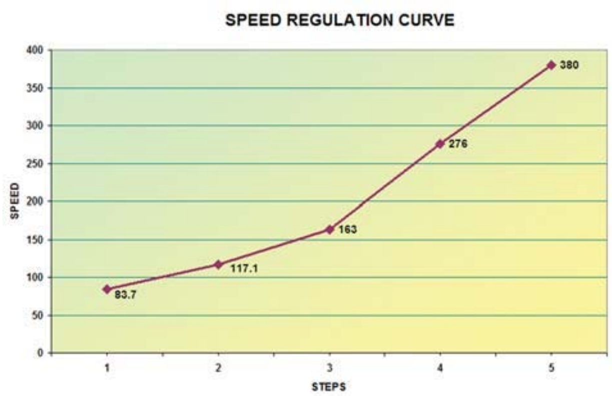


Type A fan tested on a standard regulator
Case 3: Supply voltage = 240V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM	Acc. ISI
1	79	0.120	9.48	224.10	105.6	211.00
2	115	0.180	20.70	210.10	162.9	263.75
3	138	0.220	30.36	193.70	250.0	316.50
4	158	0.240	37.92	166.70	321.2	369.25
5	230	0.290	66.70	0.06	422.0	422.00

Type C fan tested on a standard regulator
Case 1: Supply voltage = 220V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	82	0.120	9.84	221.300	83.7
2	109	0.160	17.44	194.500	117.1
3	131	0.200	26.20	179.600	163.0
4	149	0.220	32.78	155.800	276.0
5	219	0.270	59.13	0.056	380.0



Fan Regulators

Type C fan tested on a standard regulator
Case 2: Supply voltage = 230V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM	Speed Acc. ISI
1	81	0.290	8.91	250.000	87.8	191.35
2	115	0.230	19.55	199.500	127.0	239.18
3	136	0.210	28.56	193.000	198.0	287.02
4	155	0.170	35.65	158.900	290.0	339.80
5	230	0.110	66.12	0.075	382.7	382.70

Type C fan tested on a standard regulator
Case 3: Supply voltage = 240V

Regulator Number	Voltage V_F Volts	Current Amps	Power Watts	Voltage V_C Volts	Speed RPM
1	84	0.120	10.08	25.900	94.0
2	115	0.170	19.55	210.400	154.3
3	140	0.210	29.40	191.700	208.5
4	156	0.220	34.32	154.300	306.2
5	240	0.300	72.00	0.068	385.0

ANALYSIS AND CONCLUSION

Why cannot a common or general fan regulator be designed?

Different types of fans have been tested using a general regulator. After analysing all data it is observed that with one standard fan regulator we can achieve speed regulation approximating a linearity pattern but cannot satisfy the ISI standards for different fans.

Full rated RPMs of different fans are different due to electrical parameters such as number of turns in the winding, number of poles, impedance, air gap between stator and rotor, etc., that vary from one manufacturer to the other. Therefore, a common, general fan regulator is unable to regulate the speed within the ISI limits.

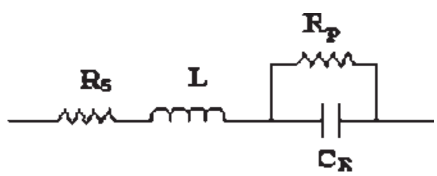
SELECTION OF CAPACITOR FOR A GOOD FAN REGULATOR

In a capacitive type fan regulator, the capacitor is the vital element. In order to design a reliable, accurate, durable and effective fan regulator, all the electrical parameters of the capacitor must be selected properly.

Basically, a fan regulator is a low power AC application for which the following parameters of the capacitor determine its working life:
1)Tan δ at working frequency.
2)Power handling capability.

Tan δ (Tangent of Loss Angle): The dissipation factor or tangent of loss angle is the power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of specified frequency.

Equivalent circuit of capacitor
$\tan\delta = \omega C R = 2 \times \pi \times f \times C \times R_S$
where, R_S = series resistance, f = supply frequency, and C = capacitance



NOTE: The measuring method shall be such that the error does not exceed 10% of the specified value or 0.0001, whichever is higher.

EQUIVALENT SERIES RESISTANCE (ESR)

The ESR is the resistive part of the equivalent series circuit and is temperature and frequency dependent. The ESR can be calculated from the dissipation factor (tan δ) as follows:
ESR = $\tan\delta/\omega C$

POWER DISSIPATION

The power dissipated by a capacitor is a function of the voltage across or the current (I) flowing through the equivalent series resistance ESR.

Fan Regulators

$P = \omega \times C \times \tan\delta \times U^2$
$P = 2 \times \pi \times f \times C \times \tan\delta \times U^2$
where f = frequency,
$\tan\delta$ = maximum value specified, and,
U = rated voltage.

BREAKDOWN VOLTAGE
The breakdown voltage is the minimum voltage required for dielectric breakdown. It follows that the operating voltage must be less than the breakdown voltage.

CALCULATION OF POWER DISSIPATION
When a capacitor is used in AC applications at high frequency, internal heating of the capacitor may follow with a possible risk of smoke or fire. This is caused by the heating effect of the current flowing through the internal resistance of the capacitor.

The following formula is used to calculate the maximum power dissipated by the capacitor:

$$P_{cmax} = \sum_{i=l}^{N} V^2_{rmsci} \times 2\pi f_i \times C \times \tan\delta_{max}(f_i) \quad (1)$$

where, P_{cmax} = max dissipated power in watts,
V_{rmsci} = RMS voltage of the ith harmonic in volts,
I_{rmsci} = RMS current of the ith harmonic in amperes,
f_i = frequency of the ith harmonic in hertz,
C = capacitance in farads,
$\tan\delta_{max}(f_i)$ = maximum dissipation factor corresponding to the frequency of the ith harmonic, and,
N = number of significant harmonics.

In sinusoidal waveform we take N = 1
Now, ΔT_{lim} = allowed capacitor overtemperature in °C.
T_h = maximum ambient temperature surrounding the capacitor, or, hottest contact point (i.e., tracks), whichever is higher, in the worst operation conditions in °C.

For T_h < 40° C
ΔT_{lim} = 40° C for film-foil polypropylene capacitors (PP), polypropylene capacitors with double sided metallised film electrodes (MMPP), and metallised polyester film capacitors (MPET).

ΔT_{lim} = 20°C for polypropylene capacitors with single sided metallised film electrodes (MPP).

For 40° C < T_h < 100° C, ΔT_{lim} = 10° C
$\Delta T_{lim} = 40\,[1-0.0166\,(T_h-40)]$ for PP, MMPP and MPET (2)

$\Delta T_{lim} = 20\,[1-0.0166(T_h-40)]$ for MPP (3)

For 100° C < T_h < 105° C
ΔT_{lim} = 0° C

The formula used to calculate the maximum power that may be dissipated by the capacitor is:
$P_{clim} = \Delta T_{lim} / R_{th}$ (4)

where, P_{clim} = maximum power that may be dissipated by the
R_{th} = thermal resistance of the capacitor in °C / watts, and,
ΔT_{lim} = allowed capacitor overtemperature in °C.

It must be: $P_{cmax} < P_{clim}$
$\Delta T_{max} = (\Delta T_m / \tan\delta_m) \times \tan\delta_{max}$ (5)
where, ΔT_{max} = capacitor overtemperature calculated using the maximum $\tan\delta$ value at the working frequency,
$\Delta T_m = T_1 - T_2$, $\tan\delta_m$ = dissipation factor of the tested capacitor measured at the working frequency and at the temperature reached by the capacitor under test, and,
$\tan\delta_{max}$ = maximum dissipation factor at the working frequency of the capacitor under test.

CALCULATION OF POWER DISSIPATION
For metallised polyester film capacitor
$\tan\delta_{max} = 0.008$ and $\tan\delta_m = 0.003$

According to equation 2,
$\Delta T_{lim} = 40\,[1- 0.0166(33 - 40)]$
$= 40\,(1 + 0.1162)$
$= 44.648°\ C$

Putting the values in equation 4,
$P_{clim} = 44.648 / 36 = 1.2402$

Putting values of V_{rms} = 250V, f_i= 50 Hz in equation 1
$P_{cmax} = 0.3454$

We see that $\mathbf{P_{cmax} < P_{clim}}$

CONCLUSION
Both metallised polyester and metallised polypropylene capacitors fulfil the requirements of our application.

However, metallised polyester capacitor scores over metallised polypropylene because its dielectric constant ε is 3.2 as compared to 2.2 for metallised polypropylene and better price.

So, for the same capacitance value MPET is smaller in area as compared to MPP because the capacitance value is given by the formula:

$$C = (\varepsilon \times A) / d$$

Though MPP has better dielectric strength, MPET is more popular in fan regulators because of smaller size and lower price.

However, if a bigger size can be accommodated then MPP is the ideal choice.

DEKI RANGE FOR FAN REGULATORS
1) Metallised polyester film capacitors.
2) Metallised polypropylene film capacitors.
Available in, both, epoxy coated and capacitor pack type.

Fan Regulators

DEKI
Film Capacitor Solutions

METALLISED POLYESTER FILM CAPACITORS
Economic type

MAIN APPLICATION: Mainly used in switch type fan regulators

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polyester film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.8% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS}$ > 2500 s at 25° C, relative humidity ≤70%

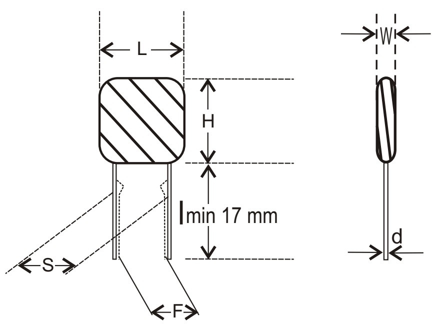
LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 V AC, **Load:** Fan Motor
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

c) Lot to lot testing: Loaded at 450 V AC at ambient temperature for 2 hours
After the test:
Δc/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm) W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5	Ordering code	Packing units Bulk
250 V AC	1	6	14	31	0.8	27.5	57 105 + 02 *^	250
MPP	1.2	7	15	31	0.8	27.5	57 125 + 02 *^	250
	1.5	7	16	31	0.8	27.5	57 155 + 02 *^	250
	2	8	17	31	0.8	27.5	57 205 + 02 *^	250
	2.2	8	18	31	0.8	27.5	57 225 + 02 *^	250
	2.4	7.5	21	31	0.8	27.5	57 245 + 02 *^	250
	2.5	9	19	31	0.8	27.5	57 255 + 02 *^	250
	3	10	19	31	0.8	27.5	57 305 + 02 *^	250
	3.3	8.5	22.5	31	0.8	27.5	57 335 + 02 *^	250
	3.6	9	23	31	0.8	27.5	57 365 + 02 *^	250
	3.7	11	20	31	0.8	27.5	57 375 + 02 *^	250
	4.3	10	24	31	0.8	27.5	57 435 + 02 *^	250



Fan Regulators

DEKI
Film Capacitor Solutions

METALLISED POLYESTER FILM CAPACITORS
Switch type

MAIN APPLICATION: Mainly used in switch type fan regulators

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polyester film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.8% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
∆c/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 V AC, **Load:** Fan Motor
After the test:
∆c/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

c) Lot to lot testing: Loaded at 450 V AC at ambient temperature for 2 hours
After the test:
∆c/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm) W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5	Ordering code	Packing units Bulk
250	1.0	6.2	14.0	27.0	0.8	22.5	02 105 + 2E1B	400
V DC	1.8	8.2	17.3	27.0	0.8	22.5	02 185 + 2E1B	400
	2.2	8.5	19.0	27.0	0.8	22.5	02 225 + 2E1B	400
	3.3	11.4	20.4	27.0	0.8	22.5	02 335 + 2E1B	400
250	1.0	6.1	13.7	31.0	0.8	27.5	46 105 + SW1A	400
V AC	1.2	6.5	15.0	31.0	0.8	27.5	46 125 + SW1A	250
	1.5	7.0	16.0	31.0	0.8	27.5	46 155 + SW1A	250
	2.2	6.8	20.2	31.0	0.8	27.5	46 225 + SW1A	250
	2.5	8.1	22.0	31.0	0.8	27.5	46 255 + SW1A	250
	2.7	8.2	22.1	31.0	0.8	27.5	46 275 + SW1A	250
	3.3	9.2	22.6	31.0	0.8	27.5	46 335 + SW1A	250
	3.5	9.4	23.1	31.0	0.8	27.5	46 355 + SW1A	250
	3.7	10.0	23.5	31.0	0.8	27.5	46 375 + SW1A	250
	3.9	10.1	23.8	31.0	0.8	27.5	46 395 + SW1A	250
	4.3	11.0	24.5	31.0	0.8	27.5	46 435 +SW1A	250
250	2.2	9.0	18.0	31.0	0.8	27.5	46 225+SW1B	250
V AC	2.5	10.0	18.0	31.0	0.8	27.5	46 255+SW1B	250
	2.7	10.5	19.0	31.0	0.8	27.5	46 275 +SW1B	250
	3.3	11.0	20.0	31.0	0.8	27.5	46 335+SW1B	250
	3.5	11.0	21.0	31.0	0.8	27.5	46 355+SW1B	250
	3.7	13.0	20.0	31.0	0.8	27.5	46 375 +SW1B	250
	3.9	13.0	20.0	31.0	0.8	27.5	46 395 +SW1B	250
	4.3	13.0	22.0	31.0	0.8	27.5	46 435 +SW1B	250

METALLISED POLYESTER FILM CAPACITORS
Socket type

MAIN APPLICATION: Mainly used in switch type fan regulators

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polyester film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.8% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

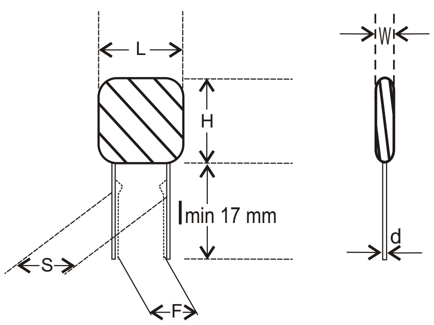
b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 VAC Load: Fan Motor
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

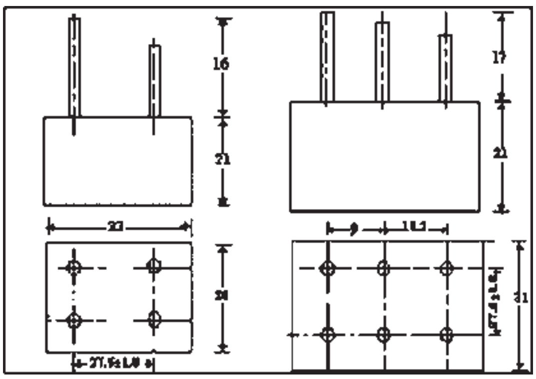
c) Lot to lot testing: Loaded at 450 V AC at ambient temperature for 2 hours
After the test:
Δc/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm)					Ordering code	Packing units Bulk
		W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5		
250 V AC	1.0	6.2	16.0	31.0	0.8	27.5	02 105 +02*^	250
MPET	1.2	8.0	18.0	31.0	0.8	27.5	02 125 +02*^	250
Series	1.5	10.0	18.0	31.0	0.8	27.5	02 155 +02*^	250
	2.2	10.3	19.6	31.0	0.8	27.5	02 225 +02*^	250
	2.4	11.3	20.8	31.0	0.8	27.5	02 245 +02*^	250
	2.7	11.8	21.5	31.0	0.8	27.5	02 275 +02*^	250
	3.3	13.7	21.2	31.0	0.8	27.5	02 335 +02*^	250
	3.5	13.8	22.7	31.0	0.8	27.5	02 355 +02*^	250

EPOXY COATED TYPE:





CAPACITOR PACK
2 Capacitor pack (MPP): Capacitance Value: 2.2, 3.1 µF
Rated Voltage: 220 V AC, Tolerance: +10%

3 Capacitor pack (MPP): Capacitance Value: 1.0, 2.2, 3.1 µF
Rated Voltage: 220 V AC, Tolerance: +10%

DEKI CAPACITOR GUIDE

Fan Regulators

METALLISED POLYPROPYLENE FILM CAPACITORS
Socket type

MAIN APPLICATION: Mainly used in switch type fan regulators

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polyester film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.1% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
∆c/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

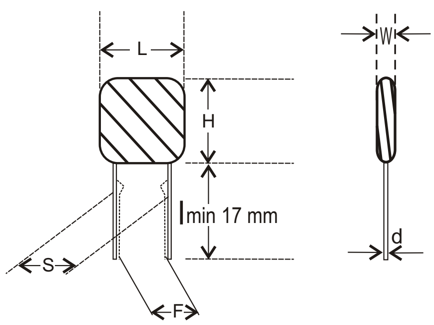
b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 VAC Load: Fan Motor
After the test:
∆c/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

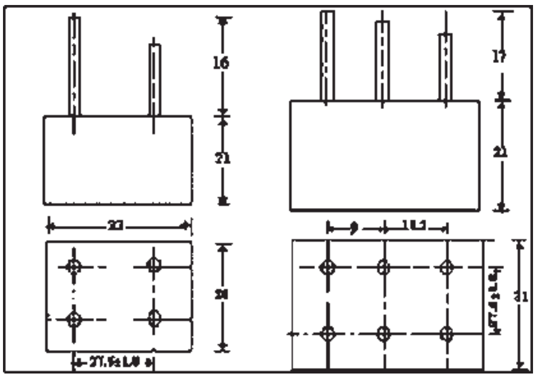
c) Lot to lot testing: Loaded at 540 V AC at ambient temperature for 2 hours
After the test:
∆c/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm) W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5	Ordering code	Packing units Bulk
250	1.0	8.0	17.0	31.0	0.8	27.5	04 105 + 02 *^	200
V AC	1.5	9.0	18.0	31.0	0.8	27.5	04 155 + 02 *^	200
MPP	1.6	10.0	19.0	31.0	0.8	27.5	04 165 + 02 *^	200
	2.2	12.0	20.0	31.0	0.8	27.5	04 225 + 02 *^	200
	2.5	13.0	21.0	31.0	0.8	27.5	04 255 + 02 *^	200
	2.7	14.0	22.0	31.0	0.8	27.5	04 275 + 02 *^	200
	3.2	15.0	23.0	31.0	0.8	27.5	04 325 + 02 *^	200
	3.3	15.0	23.0	31.0	0.8	27.5	04 335 + 02 *^	200
250	2.5	8	23	31	0.8	27.5	64 255 + 02 *^	200
V AC	4.2	13	24	31	0.8	27.5	64 425 + 02 *^	200

EPOXY COATED TYPE:





CAPACITOR PACK
2 Capacitor pack (MPP): Capacitance Value: 2.2, 3.1 µF
Rated Voltage: 220 V AC, Tolerance: +10%

3 Capacitor pack (MPP): Capacitance Value: 1.0, 2.2, 3.1 µF
Rated Voltage: 220 V AC, Tolerance: +10%

METALLISED POLYESTER FILM CAPACITORS
Ultima safety type

MAIN APPLICATION: Mainly used in switch/socket type fan regulators where no fire/explosion is allowed

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polyester film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.8% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

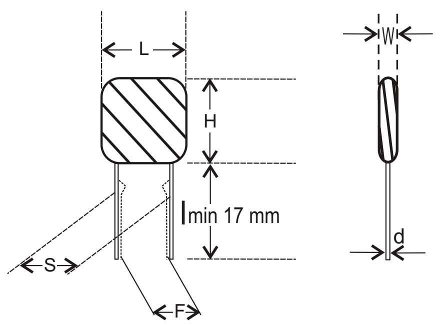
LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
Δc/c: ≤ 10% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 V AC Load: Fan Motor
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

c) Lot to lot testing: Loaded at 540 V AC at ambient temperature for 2 hours
After the test:
Δc/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm)					Ordering code	Packing units Bulk
		W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5		
250	1.5	8.5	14.5	31	0.8	27.5	86 155 + 02 *^	250
V AC	1.6	9	15	31	0.8	27.5	86 165 + 02 *^	250
	2	7.5	21	31	0.8	27.5	86 205 + 02 *^	250
	2.2	8.5	19	31	0.8	27.5	86 225 + 02 *^	250
	2.5	11	17	31	0.8	27.5	86 255 + 02 *^	250
	2.6	11	17	31	0.8	27.5	86 265 + 02 *^	250
	2.7	10	19	31	0.8	27.5	86 275 + 02 *^	250
	3.2	11	19	31	0.8	27.5	86 325 + 02 *^	250
	3.3	11	20	31	0.8	27.5	86 335 + 02 *^	250
	4	13	21.5	31	0.8	27.5	86 405 + 02 *^	250
	4.3	12	22	31	0.8	27.5	86 435 + 02 *^	250



Fan Regulators

METALLISED POLYPROPYLENE FILM CAPACITORS
Ultima safety type

MAIN APPLICATION: Mainly used in switch/socket type fan regulators where no fire/explosion is allowed

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polypropylene film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.1% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

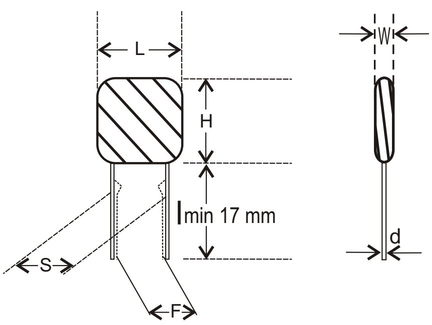
LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
Δc/c: ≤ 10% of initial value
Change in Tan δ: ≤ 0.002 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 V AC Load: Fan Motor
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.002 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

c) Lot to lot testing: Loaded at 540 V AC at ambient temperature for 2 hours
After the test:
Δc/c: ≤10% of initial value
Change in Tan δ: ≤ 0.002 of initial value

Dimension Chart

Rated Voltage	Rated cap. (µfd)	Maximum Dimensions (mm)					Ordering code	Packing units Bulk
		W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5		
250	1	8	17	31	0.8	27.5	74 105 + 02 *^	250
V AC	1.5	10	19	31	0.8	27.5	74 155 + 02 *^	250
	2.2	11.5	21	31	0.8	27.5	74 225 + 02 *^	250
	2.5	14	21	31	0.8	27.5	74 255 + 02 *^	250
	3.1	14	24	31	0.8	27.5	74 315 + 02 *^	250
	3.3	14	24	31	0.8	27.5	74 335 + 02 *^	250
	2.2	9	21	31	0.8	27.5	44 225 + 02 *^	250
	3.3	14	21	31	0.8	27.5	44 335 + 02 *^	250
	3.3	11.5	20.5	31	0.8	27.5	84 335 + 02 *^	250



DEKI
Film Capacitor Solutions

METALLISED SAFETY FILM CAPACITORS
Optima safety type

MAIN APPLICATION: Mainly used in switch/socket type fan regulators where no fire/explosion is allowed

CONSTRUCTION (DIP TYPE): Low inductive cell of metallised polypropylene film coated with flame retardant grade epoxy powder

CLIMATIC CATEGORY: 40/85/21

CAPACITANCE VALUE, RATED VOLTAGE (DC):
Refer dimension chart

CAPACITANCE TOLERANCE: ±5%, ±10%

VOLTAGE PROOF: 1.6*Ur for 2 seconds between the terminals.

TAN δ (DISSIPATION FACTOR): 0.5% (max) at 1 kHz

INSULATION RESISTANCE
Minimum insulation resistance R_{IS} measured at 100 V DC for 1 minute.
Or, time constant $T = C_R \times R_{IS} > 2500$ s at 25° C, relative humidity ≤70%

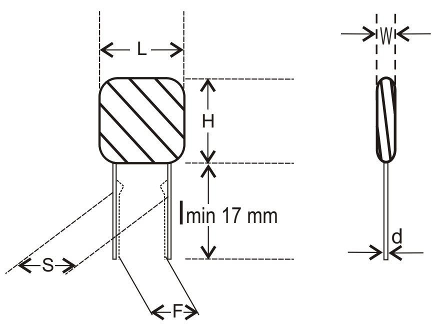
LIFE TEST CONDITIONS
a) Endurance Test: Loaded at 1.1 times of rated voltage at 70° C for 500 hours.
After the test:
Δc/c: ≤ 10% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

b) Switching test: > 20,000 cycles of 4 step / 5 step switch type fan regulator
Input supply: 240 V AC Load: Fan Motor
After the test:
Δc/c: ≤ 5% of initial value
Change in Tan δ: ≤ 0.004 of initial value
Insulation resistance: ≥ 50% of the value specified in data sheet

c) Lot to lot testing: Loaded at 540 V AC at ambient temperature for 2 hours
After the test:
Δc/c: ≤10% of initial value
Change in Tan δ: ≤ 0.004 of initial value

Dimension Chart

Rated Voltage	Rated cap. (μfd)	Maximum Dimensions (mm) W ±0.5	H ±0.5	L ±0.5	d ±0.5	S ±0.5	Ordering code	Packing units Bulk
250	1	8	17	31	0.8	27.5	69 105 + 02 *^	250
V AC	2.2	11	22.5	31	0.8	27.5	69 225 + 02 *^	250
	3.3	12	21	31	0.8	27.5	69 335 + 02 *^	250
	3.7	13	21	31	0.8	27.5	69 375 + 02 *^	250



DEKI CAPACITOR GUIDE

Fan Regulators

Deki's technology breakthrough. The first product of its kind in India.

"FLAME PROOF" Film Capacitors

In spite of all the improvements that have been made in the manufacturing process and over all quality of the metallised film capacitor, the fan regulator capacitor can still fail during its operational life time. The failure can result in the capacitor catching fire (as in the case of dip type capacitors) or the box bursting and metallised film oozing out of the box (in box type capacitors). The photographs below demonstrate these hazards very clearly.
While this type of failure is not at all acceptable, customers are still forced to use these capacitors as there is no alternative available.

Until now.

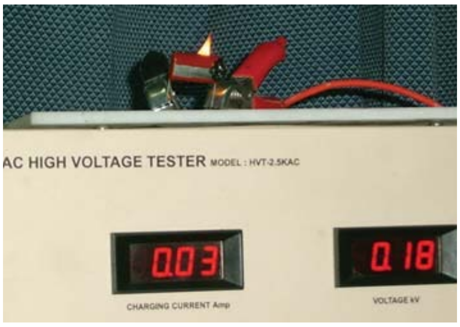
Deki has developed a Flame Proof fan regulator film capacitor. This capacitor does not catch fire nor does it burst in the box in the event of its failure. This new capacitor fails in the open mode thus fulfilling a long standing requirement of customers.

The new Flame Proof film capacitor is available in three metallised polyester series in both, dip and box:
> Economy type
> Switch type
> Socket type

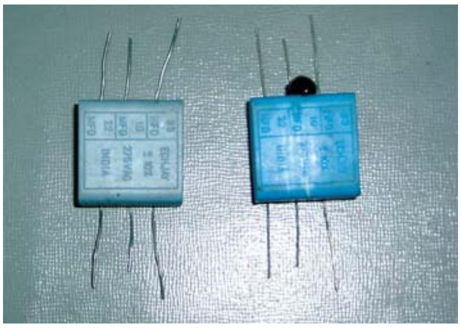
It is also available in metallised polypropylene series in dip and box versions in the socket type.

There is a marginal increase in size (still suitable for accommodation in existing design) and cost which is, however, far outweighed by the safety and peace of mind that the product offers.

NORMAL CAPACITOR



DIP TYPE



BOX TYPE

FLAME PROOF CAPACITOR

BEFORE FAILING

AFTER FAILING

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DEKI Film Capacitor Solutions