DEKI PRIMER

CFL Applications

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

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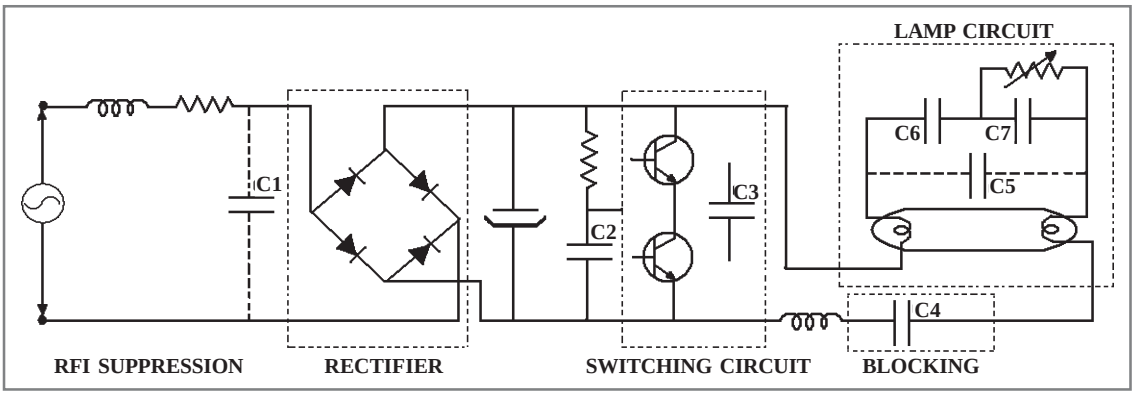
CFL Applications



Recent developments in CFL (Compact Fluorescent Lamp) ballast require a component rating of 110° C. The requirement is smaller in size and higher in wattage which increases the temperature inside the capsule, reaching 100°C in some lamps.

Choosing the right capacitor

For CFL application the major criteria are high frequency, high voltage and high temperature. Especially since the filament/striking capacitor is located near the lamp and the transformer and is, hence, subjected to a high temperature zone.

While designing the PCB layout the designer should analyse the heat generated by each component and the heat flow otherwise component reliability is bound to be affected.

For general purpose applications like blocking and coupling applications, plain polyester and metallised polyester film capacitors are used depending upon the capacitance value.

Polyester film foil capacitor is suitable for low voltage snubber and striking applications too.

For applications like snubber, striking and pre-heating applications plain polypropylene film capacitors are used because of higher voltage and high frequency requirement. PP is ideal choice for high frequency applications because of its low loss factor. Low loss factor means that during application there is less self heating of the capacitor.

The only problem with plain PP capacitor is temperature withstanding capability at 110° C where PP film starts shrinking leading to poor bonding strength between film and epoxy resin. In order to meet high temperature requirements and provide better power handling capability at the same time PEP capacitors have been developed.

PEP capacitor is a mixed dielectric capacitor - combination of polyester and polypropylene film. We can optimize the performance of the capacitor by attaining the right mix of PET and PP film. An advantage of PEP capacitors as compared to PP capacitor is better capacitance stability with respect to frequency and temperature and better operating temperature.

The capacitance stability depends upon the frequency of application, working temperature and type of dielectric used.

For example, in applications like pre-heat the capacitance stability is very important since the operating temperature range is enhanced to 110° C.

To obtain a good life time of the lamp it is important that the electrodes are carefully preheated by a certain current and during a certain time. In order to achieve this, some of the circuits are equipped with a pre-heat facility. In such a case the circuit uses C6 for pre-heat application and C7 for striking application.

If the ballast has no pre-heating function then the circuit uses only C5 capacitor for striking application.

Here is a compact guide to choosing the right capacitor for:

RFI Suppression - C1

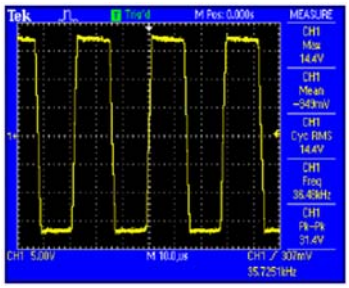
Capacitance value: 68nf to 100nf

Recommended capacitors
X2 Series for 275 VAC
MPET for 400-630 VDC.

Start Up - C2
Capacitance Value: 22nf to 100nf (63-100VDC)

Recommended capacitors
PET film foil inductive type
MPET for C > 0.082µf.

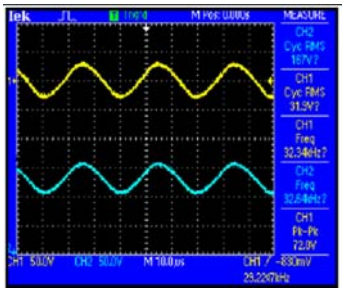
Snubber - C3



Voltage across the capacitor is approximately $150V_{RMS}$.
Capacitance Value: 0.68nf to 0.0033µf (630 - 1000VDC).

Recommended capacitors
PP film foil inductive type for temperature ≤ 85° C
PEP film foil inductive type for high voltage, high frequency and high temperature.

Blocking - C4

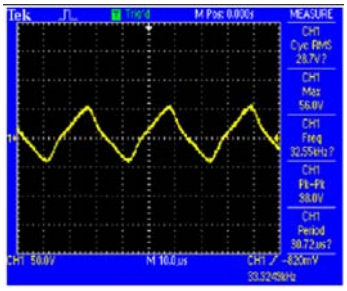


Here AC voltage super imposed on DC voltage.
V_{PK} is approximately 185V (155VDC + 30).
Capacitance Value : 0.022-0.056µf
Rated Voltage: 250-400VDC

Recommended capacitors
PET (Film/Foil)
MPET (Box Type)
MPET (Dip Type) for smart dimension.

If the ballast is equipped with pre-heat function then C6 and C7 are applicable where C6 is for pre-heat application and C7 is for striking application. With pre-heat function, V_p across the striking capacitor is reduced, so, a 630VDC rating capacitor is generally recommended.

Wave Form - C6 (Normal Operation)

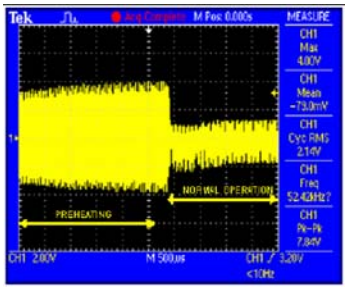


In the pre-heat function, the load across the striking capacitor is shared by the pre-heat capacitor.

If you measure the V_{RMS} across the striking capacitor for a 26 watts CFL, it will be approximately 90V to 110V, without the pre-heat capacitor.

With the pre-heat capacitor, the voltage across the striking capacitor drops to 65 V_{RMS}.

Wave Form - C7 (During Switching)

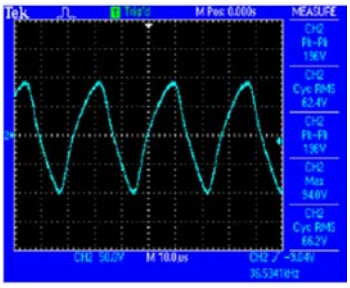


Generally, the capacitance value of the pre-heat capacitor is more than that of the striking capacitor. For example, if the value for C6 is 0.0047-0.01µf then C7 will be 0.0018-0.0068µf.

Recommended capacitors
PET film foil inductive type
PEP film foil inductive for high voltage, say $110V_{RMS}$ (special design)

During pre-heating time V_p across the capacitor is approximately 400V and V_{RMS} is 214V. Pre-heating time is approximately 3 milliseconds.

Wave Form - C7 (Normal Operation)



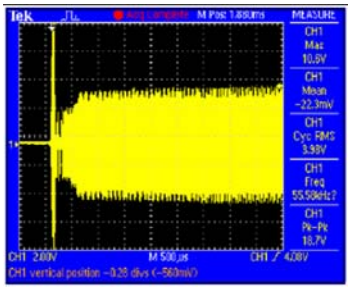
After preheating operation the lamp goes in to normal operation. V_{RMS} across the striking capacitor during normal operation is 65 V.

If the voltage is about 65 V and frequency is 40 kHz then a PET capacitor can be used.

However, if the voltage is about 110 V and the frequency is 40 kHz then a PEP capacitor is the ideal choice.

Striking Application - C5
If the ballast does not have pre-heat function then C6 and C7 are not applicable and C5 will work as the striking capacitor.

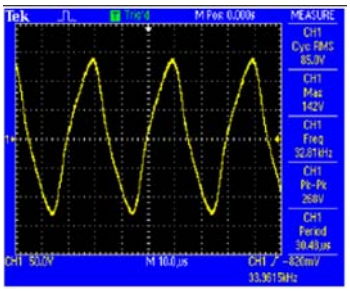
Striking Application (During Switching On)



The most widely used capacitance value is 0.0022µf to 0.0068µf (1000-1600VDC).

The rated voltage of the capacitor is selected depending upon V_p during switching on time. Generally, V_p varies from 600V to 1800.

Striking Application (During Normal Operation)



The most widely used capacitance value is 0.0022µf to 0.0068 µf.

Recomended Capacitors
PP Film foil inductive type for temp < 85° C. For high temperature, PET film foil inductive type for low frequency and low voltage, say 40kHz and $60V_{RMS}$, and PEP film foil inductive for high voltage and high frequency say 40kHz and $110V_{RMS}$.

PEP CAPACITORS (Inductive Type)

Construction: Film/foil inductive type construction with aluminum foil as electrode and PET + PP film as mixed dielectric, coated with flame retardant epoxy resin.

Climatic category: 40/100/56.

Max. operating temperature: 110° C.

Capacitance value, rated voltage (DC): 0.001µf ~ 0.01µf; 630VDC, 1000VDC, 1250VDC

Capacitance tolerance: ±1%, ±2%, ±2.5%, ±5%, ±10%.

Voltage proof: Between terminals - 2 times of rated voltage.

Tan δ: 0.25% (max.) at 1.0 kHz; 0.50% at 100 kHz.

Insulation resistance:

Min Insulation Resistance R_{IS}	V_R	$C_R \le 0.33\mu f$	$C_R > 0.33\mu f$
(or) time constant $T=C_R \times R_{IS}$	≤ 100VDC	100 GΩ	100 GΩ
at 25° C, relative humidity ≤ 70%	≥ 250VDC	100 GΩ	100 GΩ

Life test conditions
(Loading at elevated temperature)
Loaded at 1.5 times of rated voltage at 85° C or 1.5 times of category voltage at 100° C for 1,000 hours. Category voltage is 80% of rated voltage

After the test:
Δc/c: ≤3%±5 pf of initial value.
Change in Tan δ: ≤1.4 times the value measured before the test.
Insulation resistance: ≥ 50% of the value mentioned in IR chart.