TECH NOTE

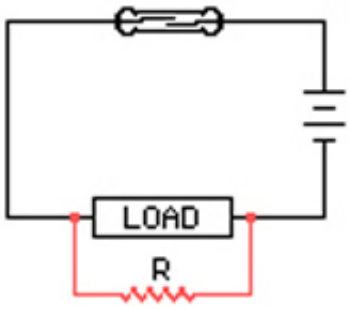
TN-120 – Protecting Relay And Switch Contacts

Overview

To suppress or eliminate the destructive arc across relay or switch contacts during the switching of inductive loads, various methods are employed. The following methods will suppress or eliminate arcing but at the same time will tend to increase the de-energizing time of the inductive load.

Case 1. DC Circuit — Resistor Across the Inductive Load

Peak transient voltage developed when the contacts open is determined by the resistance value. Note, however, that the resistor R consumes I^2R power while the load is energized.

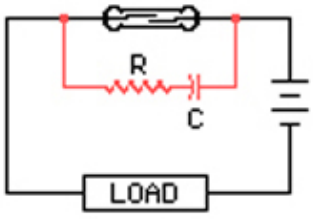


Case 2. DC Circuit — Resistor-Capacitor Across the Contacts

An initial value of R and C may be calculated from: $R = E / [10 \times (1 + 50/E)]$ and $C = I^2/10$, where R = resistance (Ω), C = capacitance (μF), I = current before closing (mA), E = voltage before closing (V).

To ensure protection with adequate arc suppression, test the circuit and adjust R and C values as necessary to eliminate arcing at the contacts.

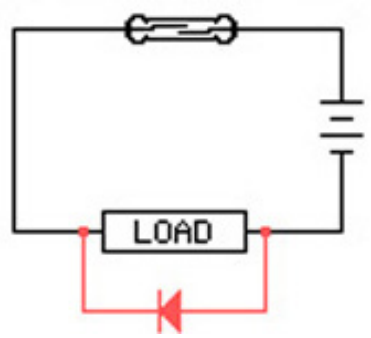
Where R = resistance, Ω
C = capacitance, uf
I = current before closing, mA
E = voltage before closing, V



Case 2: R-C snubber across contacts. Legend: R=resistance (Ω), C=capacitance (μF), I=current before closing (mA), E=voltage before closing (V).

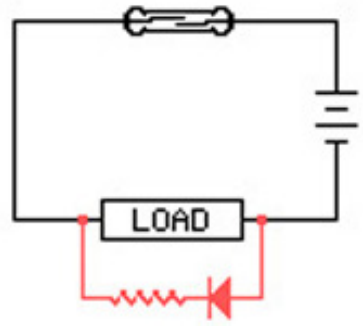
Case 3. DC Circuit — Diode Across the Load

The diode provides a low resistance path for stored energy in the load when the contacts open.



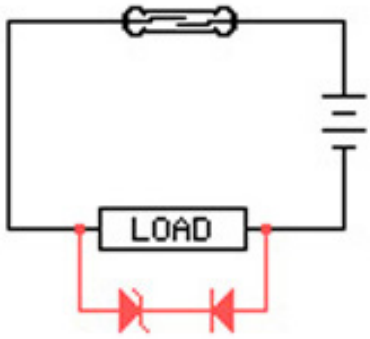
Case 4. DC Circuit — Diode-Resistor

Treat this case as similar to the diode-zener diode in Case 5.



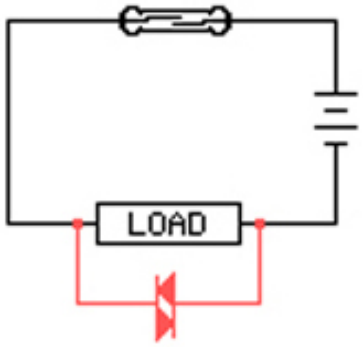
Case 5. DC Circuit — Diode-Zener Diode

This method speeds de-energization time of the inductive load.



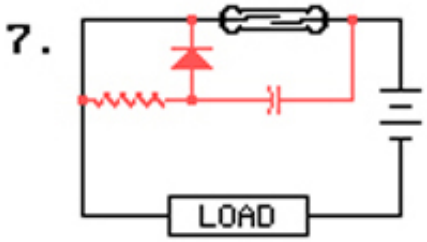
Case 6. DC or AC Circuit — Varistor Across the Load

Allowing the varistor to carry approximately 10 percent of the load current will limit the transient voltage level to approximately two times the source voltage.



Case 7. DC Circuit — Resistor-Capacitor-Diode

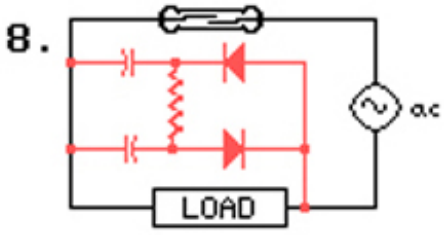
This method is for extremely inductive loads. The voltage drop across the opening contacts is zero. C is chosen so that the peak voltage to which it charges does not cause diode, contact gap, or capacitor breakdown.



Case 8. AC Circuit — Resistor-Capacitor-Diode

Also for extremely inductive loads. This arc suppression circuit can be connected across the load or contact gap. Typical component values for 120 VAC applications: diode PIV = 400 V, current rating 1A; C1 and C2 voltage rating 200 V; R1 = 100K, 1W.

Note: Peak values of voltage and current must be used to calculate values of R and C to suppress AC loads. Use Case 2 formula. Also read Tech Note 101.



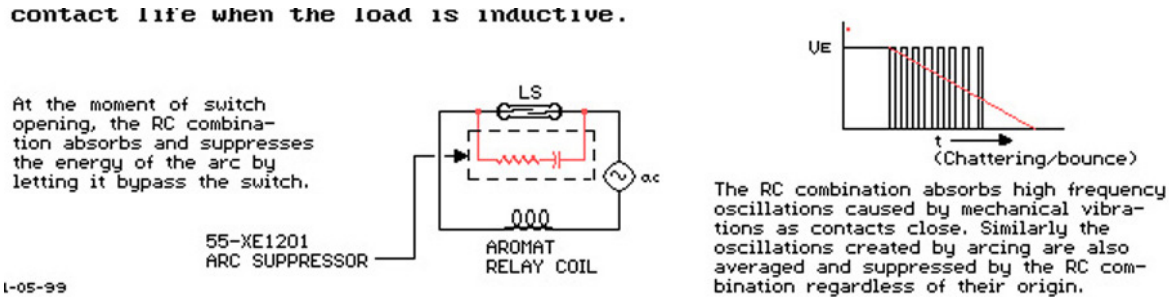
Case 9. AC Circuit — Reed Switch Controlling AC Relay Coil (Test Data)

Perhaps the most common application has the reed switch switching a small AC relay or solenoid. In a recent evaluation test, five AROMAT type HL 2-P-AC115V control relays were connected as shown. The coil of each relay was connected to a Compac 10-782-PP liquid level switch. The floats were raised and lowered by a mechanical arm connected to a gear motor to simulate the rise and fall of liquid. Cycle time was approximately 2 seconds. An electro-mechanical counter recorded each rise and fall cycle.

Tests with and without contact protection were conducted. Suppression components consisted of a 120 ohm resistor and .1 MFD ceramic disc capacitor. See CEI product 55-X1201 Arc Suppressor.

Results without contact protection: Five switches developed "stuck closed" welded contacts. Three failures were noted at 99,672 / 157,184 / and 1,222,535 operations respectively.

Results with contact protection: No failures were noted. The test was stopped at **1,800,100 operations.** Clearly, contact protection extends contact life when the load is inductive.



Case 9 test circuit: Reed switch (LS) driving AROMAT relay coil with 55-XE1201 arc suppressor. RC combination absorbs arc energy at contact opening. Right: VE/t waveform showing chattering/bounce suppression.

Determining RC Values

Customers who wish to provide their own version of arc suppression may find the table and formulas provided below of value.

DETERMINING RC VALUE

SOURCE VOLTS	LOAD CURRENT – AMPERES										R+C VALUES
	0.05	0.1	0.2	0.3	0.5	1.0	2.0	3.0	5.0		
120VAC or 120VDC	0.01 + 470	0.01 + 470	0.01 + 220	0.01 + 120	0.022 + 120	0.1 + 47	0.3 + 47	0.5 + 47	1.0 + 10	MFD + OHMS	
240VAC or 240VDC	0.01 + 470	0.01 + 470	0.01 + 470	0.01 + 470	0.022 + 120	0.1 + 120	0.3 + 120	0.5 + 47	1.0 + 47	MFD + OHMS	

$$C = \frac{I^2}{10}$$

$$R = \frac{V}{10\left(1 + \frac{50}{V}\right) I}$$

C= Capacitance in MFD
I= Load Current in Amps
R= Resistance in Ohms
V= Source Volatage

RC value determination table and formulas. C = I²/10 (MFD), R = V / [10(1 + 50/V)] × I (Ω). Table covers load currents 0.05–5.0 A at 120 VAC/VDC and 240 VAC/VDC.

In general, the RC determining formula is regarded as quite complex, but since the RC combination has the decisive effect of integrating the rapid changes to the waveform to a smoothed average, the determination of RC values by complex formula becomes unnecessary.

It is possible to select a suitable combination using the chart or formula. Keep in mind that there is no one exact value of arc suppressor that will satisfy all applications. Therefore, the chart and formula are merely a starting point. Final selection must be evaluated in the application to determine its suitability.

> **Key Reminder**
>
> Test the arc suppressor in your actual circuit. Component values from the table are starting points only. Adjust R and C until arcing is eliminated as confirmed by the neon lamp test described in Tech Note 101.