How to design an RC snubber for a solenoid relay driving an inductive load?

Asked 9 years, 2 months ago Active 4 years, 5 months ago Viewed 65k times

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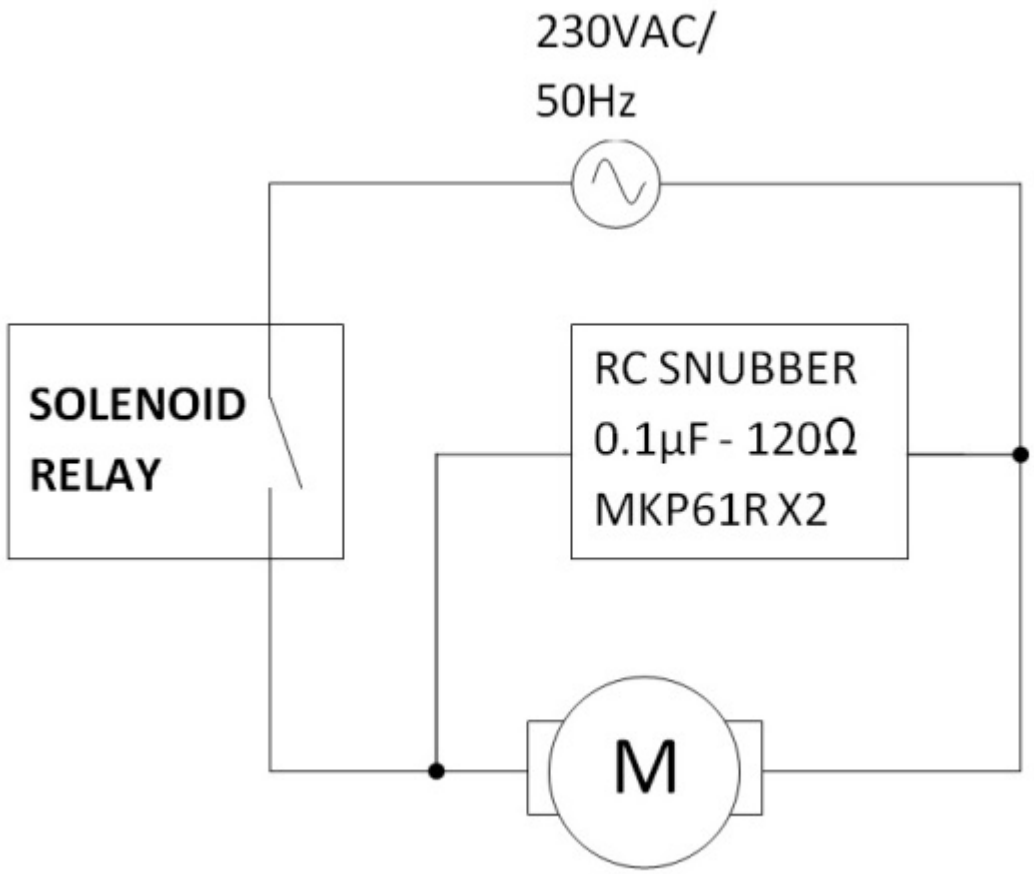
16

I read up that switches driving inductive loads need to be snubbed and an RC pair seems to be the best (cheapest?) option. I have a large-ish AC induction motor (for a refrigerant compressor) that is being switched by a solenoid relay (about once every 30 minutes). Motor specs are like this:

Power:1500W (Input power. As read out on a watt meter.)
Max. Current: 10A
Rated Voltage: 230VAC/50Hz.

I came across a solution like this:



1. How do I select a suitable snubber? A very common combo seems to be 0.1uF - 120Ohm. But I couldn't justify it.
2. Should it be in parallel to the switch or the load?

inductive snubber

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edited Jun 28 '13 at 9:30
Anindo Ghosh
49.4k 8 101 196

asked Sep 26 '12 at 6:18
Sohail
725 1 8 18

2 It should be series RC in paraller with the motor, since when the switch opens it won't make any sense there. About the values, this can be a tinkering exercise if you don't have all the motor's data. But, as a start, the R should be roughly more than 10 times the motor's resistance (not impedance) and the C should be chosen such that the time constant is enough to smoothen the switching transients. This means it shouldn't be too high a value so R shouldn't get too much power to dissipate (waste), and not too small either to not damp the ringing. – Vlad Sep 26 '12 at 8:09

Thanks Vlad! I see the intuitive logic you have mentioned here about the capacitor. But I think I'll rather just go with what has been used for long. :-). But hey, the RC could be in parallel with either the switch or the motor as explained by Russell below. And I also came across a snubber datasheet that mentioned that both are okay but across the switch is 'preferable' - no reasons mentioned. Thanks again. – Sohail Oct 1 '12 at 2:56

Well, if I was spartan in my explanation it was because many times (out of my tries) I had to deal with no-name motors that had no data and various things burned all-around. As for the placement, I considered the drawing you provided, in which case the switch doesn't need protection, but the others do because of it, therefore making its placement useless there. At any rate, the purpose needs to be accomplished somehow, and this was the answer that surfaced at the time. Good luck. – Vlad Oct 1 '12 at 7:26

Hey. I'm really curious to know if you went ahead with it and what you ended up with. I have a similar problem and was wondering if you went with the above-mentioned values and if it still works? – ti_chris Aug 4 '20 at 6:57

@ti_chris - Hi... Yes I did but with the snubber across the relay contacts instead of across the motor. It works fine but there was no doubt about it anyway since this solution has been in use for white goods for all these years. My question was only about how they got the values for the components. – Sohail Jan 31 at 17:48

3 Answers

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20

The values used will often be OK.
A larger than usual motor inductance may cause problems.

The snubber's job is to protect the switch contacts from inductive turnoff transients from the motor. Stopping the transient at source (across the motor) or at destination (across the contacts) both work. Arguably, having it at the switch is better as it deals with the energy that will do damage, as opposed to energy that may do damage, so it is more focused and it also then deals with other spikes that may happen along.

If you look at your circuit you'll note that in both cases the snubber connects from the motor-switch connection point to one leg of the mains. If the mains impedance is low at the spike frequency (-ies) then both are about equivalent.

The circuit current continues instantaneously at switch off. If it all flows through the snubber then it will pass through the 120 ohm resistor, so the voltage spike will *initially* will be $V = IR = 10\text{A} \times 120\Omega = 1200\text{V}$. While that is a lot it is usually within the switch break capability (or else), and there are usually other impedances present which will also help to damp it.

The snubbing current will flow only until the capacitor charges to the driving voltage. If the motor inductance is large the capacitor may charge to a higher or much higher voltage.

The capacitor needs to be large enough to not be charged to the point where current decays through charging of the cap before the resistor dissipates the energy. To be sure that the component values present will do the job, you need to know motor inductance.

Energy in inductor is $E = \frac{1}{2}LI^2$

Capacitor will "ring" with an energy of $E = \frac{1}{2}CV^2$

The resistor needs to dissipate this energy.

Energy =

$$\frac{1}{2}Li^2 = \frac{1}{2}CV^2$$

$$\Rightarrow V = \sqrt{\frac{Li^2}{C}}$$

Then there is some L/R time constant as well and ...

You can start to calculate this (if you know L) or simulate it, *but* in most cases the values shown are OK for typical equipment.

Place a scope across the contacts. What peak V do you see (use a suitable probe!). Do the contacts spark? They shouldn't.

Note that increasing C improves snubbing action *but* also increases losses from the mains

> Dario said: One problem with placing the RS across the switch is that now you have some current in the circuit in the switched off mode. ...
>
> User_long_gone responded: I'm absolutely certain that the 4-5 MILLIAMPS of current flowing through a 0.1 microfarad capacitor at 60 Hz will present no problem to a motor circuit. Wasteful of energy? It's less than 1/2 watt.

It's worth noting that

1. The snubber across the motor may not bother the motor itself but may well severely bother anyone silly enough to think that the switch being off means that the circuit is "safe" or "dead". If the switch is in the phase/live lead the motor side of the switch may be near ground due to relative impedances. But there is no certainty that this will always be the way the connection is made - even if regulations say that it should be.

2 "Even" 1/2 a Watt of pointlessly wasted energy in an appliance is frowned on in modern scenarios.

Share Cite Follow edited Dec 2 '15 at 5:17 answered Sep 26 '12 at 8:12

Russell McMahon ♦
141k 16 194 359

Thanks Russell! I could find a datasheet for the motor (sealed hermetic compressor actually) but they just haven't mentioned the inductance. But I think I'll take the common 0.1uF and 120Ohms for now since they have been used in so many of such applications. And the relay is a completely sealed one with an opaque case. So I don't see the contacts. But since these appliances (the relays at least) last for years, I don't think there's any sparking. Thanks again. :-) – Sohail Oct 1 '12 at 2:48

If the motor inductance is 200mH, the 0.1uF snubber cap would have to charge to 4500V to contain all the energy that the inductance stores at 10A. Sure there will be some losses in the 120 ohm resistor while charging the cap, but still I worry that 0.1uF is too small for such a large motor. 200mH is just a guess though, to be sure one would have to know the real value. – avl_sweden Jul 22 '15 at 20:36

@avl_sweden Yes and/but ... : Snubbers are always compromises. As noted, you need to plug in value if known and see if the results are acceptable in your case. In many cases the values given work "well enough" in practice. The main aim is to prevent switch contact damage and if you can go from an arc / spark situation to none(visible) then it's a good start. Switch voltage may still conceivably be high and damaging but not visible and a sope can be a useful check (use a suitable probe and be aware of HV scope safety issues). – Russell McMahon ♦ Jul 23 '15 at 4:54

1 @NicolasD ... digs in memory ... I guess I got that 1//2 Watt from USER59273's question (maybe not) and didn't calculate the actual value. So, yes, you are correct - IF the capacitor & series resistor were across the switch it would only dissipate mWs (under 10mW at a quick glance - maybe less). But it would still have the prospect of giving a careless investigator a nasty bite - notionally under the

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One problem with placing the RS accross the switch is that now you have some current in the circuit in the switched off mode. This may actually be good if your motor requiers pre-heating, but it is somewhat wastefull with energy.

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answered Sep 20 '13 at 15:04

Dario

31 1

I'm absolutely certain that the 4-5 MILLIAMPS of current flowing through a 0.1 microfarad capacitor at 60 Hz will present no problem to a motor circuit. Wasteful of energy? It's less than 1/2 watt. – user59273 Nov 28 '14 at 22:38

2 @user59273 seems to have vanished and Daio has not been back - but it's worth noting that the snubber across the motor may not bother the motor itself but may well severely bother anyone silly enough to think that the switch being off means that the circuit is "safe" or "dead". If the switch is in the phase/live lead the motor side of the switch may be near ground due to relative impedances. But there is no certainty that this will always be the way the connection is mde - even if regulations say that it should be. – Russell McMahon ♦ Jul 23 '15 at 5:50

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Distance and physical wiring may play an important role when choosing where to place the RC snubber, when considering across the switch contacts vs across the inductive load. If the RC snubber is placed across the inductive load, the arc suppression benefits of the RC snubber may diminish as distance increases between the switch contacts and the load, as wiring may be seen by the contacts as an inductance, and may still experience arcing. Evaluate if this applies to your application.

Hardwired remote controls are an example where said distance plays a role.

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answered Aug 2 '15 at 15:49

Carlos Patterson

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