# in practice

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## RELAY SPEED-UP CIRCUIT

*FOLLOWING YOUR item in January 2002 about suppressing voltage spikes when relays are switched off, how can I make a relay pull-in faster? The antenna changeover relay on my linear amplifier is rather slow, and when my transceiver keys it, there is an RF spark. I think this is because the RF power appears before the relay has fully changed over.*

YOU'RE PROBABLY RIGHT. Many modern transceivers provide a delay of 10 - 15ms between key-down - or pressing the PTT or transmit button, or tripping the VOX - and the start of actual transmission. But, since many antenna changeover relays take 20 - 30ms to pull in, you can indeed expect some RF arcing. I will describe a modification that gives you a sporting chance of speeding-up the relay so that it has changed over before the RF arrives.

To make a relay close faster, you need to build up the magnetic field in the solenoid very quickly, but the large inductance of the solenoid fights back against any change in current. There are three ways to overcome this: the classic way, the dirty way and the clever way. The classic way is to operate the relay from a higher voltage than normal, and use a dropping resistor (R1 in **Fig 1**) to establish the correct steady-state current through the coil. The current through the relay coil ends up at the same value, but it gets there much more quickly if you supply the relay from a higher starting voltage. Fig 1 gives a family of curves showing how the current in a typical relay builds up. The slowest build-up is when the relay is operated from its normal voltage V, and with R1 short-circuited. The fastest build-up shown is when the same solenoid is operated from a supply voltage of 5 x V, with R1 equal to four times the solenoid's internal resistance, so that the final current is the same as before. The intermediate curves are for 2 x V and 3 x V. If you compare the times taken to reach, say, 90% of the final steady-state value, you find that the speed-up ratio is simply equal to the voltage ratio (and if you know your differential calculus, here's your cue to say "Yes, obviously"). However, this method has certain disadvantages, especially if you wish to modify an existing amplifier - you have to provide a higher-voltage source, often at substantial current, and then throw away a lot of heat in R1 while the relay is energised. Also you have to be prepared to switch this higher voltage, and to handle the switch-off transient as discussed in January.

The dirty way? Oh, simply run the relay from about 2 x V all the time, and hope the coil doesn't burn out!

Now for the clever way. This one came from K1KP, and it's a way of effectively doubling the relay voltage for the first few milliseconds when it matters, without any of the disadvantages of Fig 1. **Fig 2** shows the circuit. Initially the PTT line is un-grounded, and C1 charges up to the full supply voltage V via the relay solenoid RL1, D1 and D2. TR1 has no forward base bias at this time, and does not conduct. Activating the PTT line grounds the positive terminal of C1, so that the negative terminal of C1 takes the emitter of TR1 down below ground potential, almost to -V. This causes base current to flow into TR1, which turns fully on so that its collector is also very close to -V. At this moment the relay RL1 sees +V on one terminal and -V on the other, a total of twice the normal voltage, so it pulls-in very smartly. This golden moment doesn't last, of course, because the relay current will discharge C1 within a few milliseconds. D1 and D2 were both reverse-biased while C1 was pulsing the relay, but when C1 discharges, D1 starts to conduct again and holds the relay in at its normal operating voltage for as long as the PTT line is grounded. Note that R1 is essential to allow the base of TR1 to follow the emitter down towards -V. 1kΩ is a suitable value.

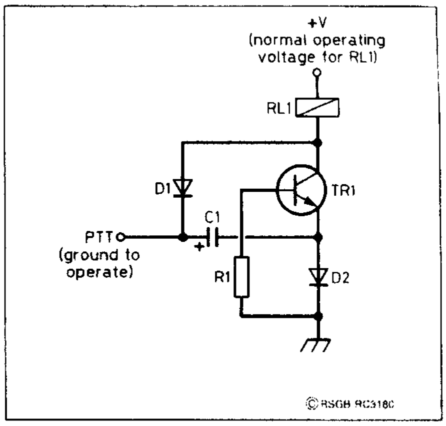


Fig 2: K1KP's relay speed-up circuit will roughly halve the pull-in time, while still using the normal supply rail. This makes it ideal for modifying existing rigs.

The degree of speed-up you can achieve with this circuit depends partly on how quickly it pulses current into the solenoid, and then partly on the mechanical reaction time to move the contacts. Based on detailed simulations of the transient behaviour, the circuit of Fig 2 is equivalent to operating the relay from about three times its normal supply voltage with a series resistor (see dashed line of Fig 1). The speed-up of contact closure seems to be about a factor of two, depending on the mechanical design of the relay.

When the PTT line is released, C1 recharges quickly through RL1, D1 and D2, so the circuit is soon ready for a repeat operation. The unexpected bonus is that when you release the PTT, you don't need to worry about handling the energy stored in the solenoid's magnetic field (see January) because it all goes into recharging C1. This makes the field collapse very quickly, with only a small voltage transient from the back-EMF, so the circuit also shortens the relay's drop-out time. The value of C1 is not very critical. Most antenna relays would need 50-100µF, or possibly more if you're driving the input and output relays in parallel. If C1 is too small, the circuit won't pulse all the way down to -V, and the back-EMF transient on switch-off will increase. If C1 is larger than necessary, it pulses closer to -V and stays there longer, but the critical rising edge of the current waveform hardly steepens at all. The drop-out time extends by a few milliseconds if the value of C1 is very large, and the recovery time before a repeat operation also increases, although this is not normally a problem. If you want full break-in CW at very high speed, you might then need

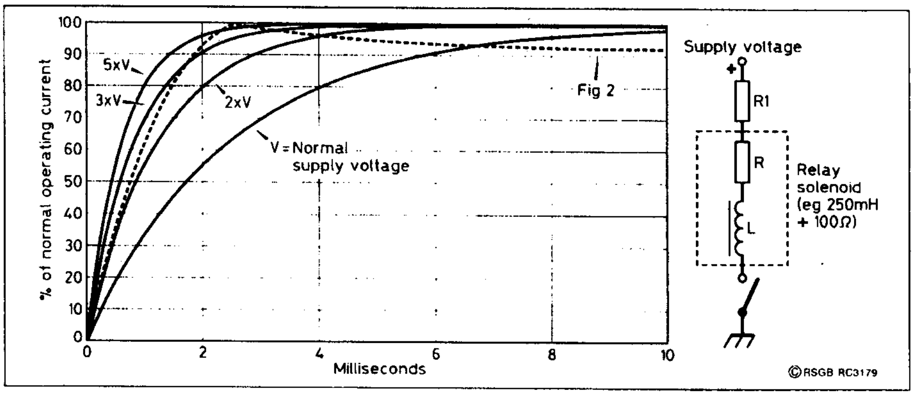


Fig 1: Family of curves showing how the rise-time of current in a relay coil can be speeded-up by supplying the relay from a higher voltage through a dropping resistor. R1 is adjusted so that the final current is the same in all cases.