

Solving RFI and noise problems with NJM3717 and NJM3770A

The NJM3717 and NJM3770A are chopper (switch-mode) type stepper motor drivers. Due to the operation of these circuits, electromagnetic as well as capacitively coupled noise can be generated by the ICs during switching and may be radiated via surrounding wires and PCB copper tracks.

Magnetic noise is generated by loops on the PCB and couples into nearby circuitry in the same fashion as a transformer couples power between two windings. The general method to avoid magnetically coupled noise is to route supply rails close to each other on the PCB and to make current loops as physically small as possible.

Capacitive noise is coupled between adjacent copper tracks or components/component leads on the PC board. Especially sensitive situations are when two tracks run in parallel on each side of a board or on nearby layers. Capacitively coupled noise may be eliminated by introducing ground planes between power rails and low level circuitry on multilayer boards. Separating low level circuitry from power circuits by guarding or screening may also be needed.

To reduce potential interference when using the NJM3770A (or the NJM3717/2), there are a few basic rules to follow. Please refer to the figure 1 and the points of discussions indicated by numbers 1 through 6.

1. Recirculating current path

During the turn-off mode of the IC (a complete description of the operation of the NJM3717/3770A can be found in the data sheets) the motor current recirculates through the external free-wheeling diodes as indicated by the magnetic field which can induce noise voltage in adjacent circuitry. To reduce potential problems, the recirculation diodes should be located as close to the IC as possible.

2. Filtering of power supply rails

An LC filter in the positive supply rail reduces noise that may be spread to other circuits. Suitable values are: inductor, 10 - 100 mH; and capacitor, 10 mF + 0.1 mF. The LC filter should be located as close to the circuit as possible, and the capacitor connected to power ground.

3. Grounding

It is essential to understand that the power ground of the circuit is at the point where the sensing resistor RS connects to the negative supply. Thus, this ground connection should be separated from all other ground returns, especially those of sensitive low-level circuits. Signal ground is at the ground pins of the stepper motor driver circuit, and should be connected to a common ground point, preferably close to the power connector on the PC board.

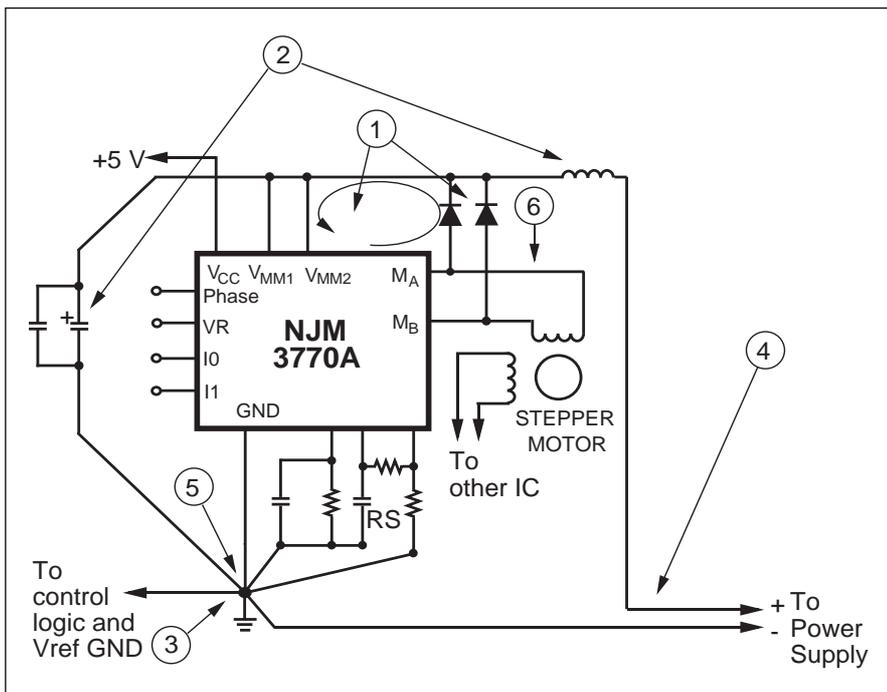


Figure 1. Circuit showing proper printed circuit board layout design.

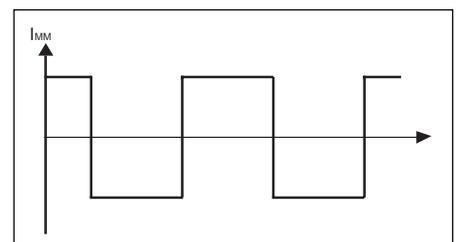


Figure 1, normal motor current at full step

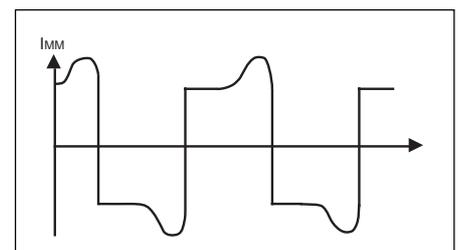


Figure 2, motor current at full step with resonance problem.

4. Power supply connection

To minimize magnetic interference from the power supply rails, the positive supply and the power ground return copper tracks should be routed closely to each other on the PC board. Compare this to the “twisted wire” technique. Best result will be achieved if the two tracks run in parallel in separate layers on a multilayer PCB.

5. Signal ground

Ground reference for the logic inputs, the reference voltage ladder resistor network and the current selection comparators, are all connected to the ground pins of the device (see data sheet for pin-out diagrams for DIP and PLCC packages respectively).

This ground should be connected to the same logic ground as the control logic which drive the logic inputs (Phase, I0 and I1). This is also the ground of the voltage reference, usually the +5 V rail.

There are two important aspects of the signal ground:

5a. During phase shift (when Phase changes state) the motor current will flow through signal ground and cause ground current transients. This means that the signal ground path on the PCB must be kept as short and low impedance as possible to avoid noise that can be capacitively coupled to sensitive circuits.

5b. It is imperative that the ground of control logic and the signal ground of the stepper motor IC are at equal ground potential. Different ground potentials can result in permanent damage of the ESD protection diodes at the logic inputs of the stepper motor IC.

6. Motor leads

The motors leads should be wired for minimal interference. Shielding may reduce noise further. RC or LC filtering of the motor outputs may be needed in severe cases. Rule of thumb: Cut-off frequency of filter shall be at least 10 times chopper frequency.

Resonance In A Stepper Motor System

All mechanical systems have a resonance frequency. It is always important to avoid oscillations at this resonance frequency. The resonance in a stepper motor system occurs often as an unwanted current rise in the end of each step.

Why does the current rise occur

If the stepper motor system operates close to its resonance frequency the motor will start to oscillate for each step. This oscillation will make the motor work as a generator and the motor current will rise.

How good the damping of this current rise and the oscillation is depending on the regulation loop in the driver system. If the minimum duty cycle is close to zero we get a good damping and as the minimum duty cycle increase we lose damping performance.

Why Is Microstepping Better

Microstepping does not only give better resolution in a stepper motor system, it also reduce resonance problems. In microstepping the energy in each step (microstep) is much less than in fullstep or halfstep. Less energy in a step will give less oscillation and therefore less resonance problem.

Mechanical Damping

If You have a unloaded motor and add some kind of mechanical load to it. This load will introduce a damping factor in the stepper motor system.