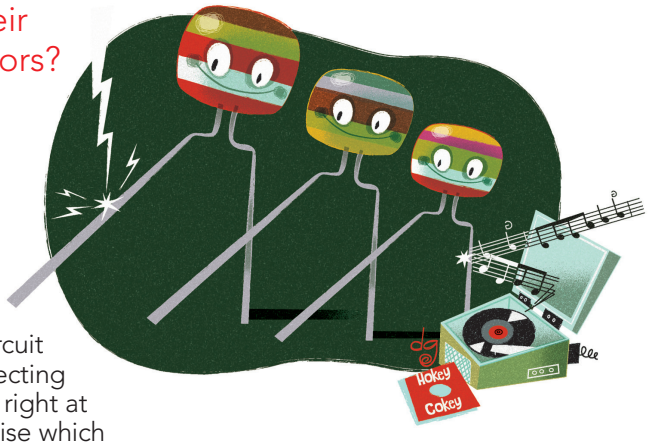
RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

In and Out – or – Why Have a Capacitor?

Q. Why do ICs need their own decoupling capacitors?



A. To keep the HF in and the HF out. (This is not a claim that capacitors dance the Hokey Cokey.)

There are two important reasons why every integrated circuit (IC) must have a capacitor connecting every power terminal to ground right at the device: to protect it from noise which may affect its performance, and to prevent it from transmitting noise which may affect the performance of other circuits.

Power lines acting as antennas can pick up high-frequency (HF) noise, which can couple by electric fields, magnetic fields, electromagnetic fields, and direct conduction from elsewhere in the system. The performance of many circuits is impaired by the presence of HF noise on their supplies, so any HF noise which might be present on an IC's supply must be shorted to ground. We cannot use a conductor for this as it will short circuit dc and blow fuses, but a capacitor (usually in the 1-nF to 100-nF range) blocks dc while acting as a short circuit for HF.

1 cm of wire or PC track has ~8 nH inductance (5 Ω at 100 MHz), which is scarcely a short circuit. A capacitor acting as an HF short circuit must have low lead and PC track inductance, so each supply capacitor must be located very close to the two terminals of the IC it is decoupling. It is also important to choose capacitors with low internal inductance—usually ceramic ones.

Many ICs contain circuitry which generates HF noise on their supply. This noise must also be short circuited by a capacitor across the supply before it can corrupt other parts of the system. Again, the length of leads and PC tracks is critical; not only do long leads act as inductances and make the short circuit less than perfect, but long conductors act as antennas, transmitting HF noise to other parts of the system by means of electric fields, magnetic fields, and electromagnetic radiation.

It is therefore very important that every supply terminal of every IC should be connected to its ground terminal (or terminals, which must all be joined together with broad, low inductance PC tracks so that there is no resistance or inductance to prevent them all behaving as a single low-impedance unipotential star point) with a very low inductance capacitor.

To Learn More About Decoupling Capacitors
http://dn.hotims.com/34953-100

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Have a question involving a perplexing or unusual analog problem? Submit your question to: www.analog.com/askjames

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