

Rarely Asked Questions—Issue 123

Unused Pins

By James Bryant



Question:

If grounding is one of the most common causes of analog problems, what is the next most important?

Answer:

The misconnection of unused IC terminals.

I spent the weekend before writing this RAQ at the Oktoberfest in Munich,¹ the original Oktoberfest and the largest in the world. I did not go just for the beer, although Bavarian beer is extremely good, but to meet a group of German friends and (ex-)colleagues. Most of us were, or had been, analog applications specialists and the conversation over the beer and brass bands covered the sillier problems we had seen during our careers. A surprising number involved incorrect treatment of unused IC terminals, so although the topic was covered in RAQs 3,² 46,³ 70,⁴ and 119,⁵ I think it needs to be revisited—just like the Oktoberfest.

One problem arises from the lack of standardization on data sheets, even from the same manufacturer. It is common for an IC to have one or more terminals that are marked “NC” on the pinout diagram. This can mean two different things, and very often the data sheet does not explain which. The more common meaning is that there is no connection from the IC chip to that pin. In this case it is best to ground it, but in most cases it will do no harm if another track running in that part of the PCB is connected to it instead.

But it is by no means unusual for NC to mean that the terminal carries an internal connection that is used during manufacture for calibration or test but must not be connected to anything during normal use. If a terminal is labeled “IC” (internal connection) this is almost invariably the case. Making a connection to such pins may cause incorrect operation or even destroy the device. If there is no indication on the data sheet

which meaning of NC applies, such pins should be left unconnected—or the manufacturer’s product engineers consulted for clarification.

In general, unused inputs should not be left open circuit:

- Digital circuitry often has inputs that are used to configure its operation and are permanently connected to Logic 0 or Logic 1. Although such inputs never change their logical state, they are not unused and must be connected as the device operation requires. Real unused logic inputs are ones whose logic state does not affect the particular application required—these should be connected to fixed Logic 0 or Logic 1 potentials and not left floating.⁶ If an unused logic input has internal pull-up or pull-down resistors/currents, it is not necessary to connect to the pin, but if the pin is likely to be exposed to electrostatic or RF fields, it may be sensible to do so by making an external connection to V_{DD} or V_{SS} , respectively.⁷
- Unused analog signal inputs should usually be connected to a dc potential but may sometimes need to be grounded at ac only by a capacitor—RTFDS.⁸ In many cases this dc potential may be a power supply or ground, but for reasons that are discussed in more detail in RAQ 46,³ amplifier inputs often need different treatment. RAQ 3² explains why unused analog signal connections to analog switches and multiplexers must *never* be left floating but should always be connected to ground or some other convenient potential.

Unused voltage outputs rarely need termination and can usually be left floating, but some amplifier outputs (and this includes the outputs of buffered voltage references) may oscillate without capacitive or, very occasionally, resistive loading. Such oscillation may disrupt the operation of other parts of the system and must be prevented by the use of an appropriate capacitor or resistor.

Unused current outputs often require a pull-up (or pull-down) connection to a supply or to ground to prevent incorrect operation of other parts of the circuit. Kirchhoff’s law says, in effect, that a current always has to go somewhere—it cannot just disappear! This pull-up/down will generally be a short circuit but may sometimes need to be a resistor so that power dissipation takes place in the resistor and not in the IC chip.

The real message from all the above advice is that even if a particular terminal of an IC is unused in an application it is still necessary to understand its function, what potentials are (or should be) present on it, what currents may (or *must*) flow to/from it, how sensitive it is to electrostatic or RF influences, and if it requires capacitive or resistive loading of any sort. In other words, as we have so often said before, “Read the Friendly Data Sheet”⁸—and do what it tells you.

References:

- ¹ [Oktoberfest 2015](#).
- ² Bryant, James. [“Isolating the Key Detail \(or Lunching with a Mermaid and Pickled Herring.”](#) *Rarely Asked Questions*, Issue 3.
- ³ Bryant, James. [“What Shall We Do with an Unused Op Amp?”](#) *Rarely Asked Questions*, Issue 46.
- ⁴ Bryant, James. [“Do Something with that Unused Pin!”](#) *Rarely Asked Questions*, Issue 70.
- ⁵ Castro, Gustavo. [“The Ingenious Gentleman and the Mysterious Paddle.”](#) *Rarely Asked Questions*, Issue 119.
- ⁶ Very occasionally digital circuits have “tristate” inputs where the three states are Logic 0, Logic 1, and open circuit. In such cases it may be necessary to leave an unused pin open circuit, but if at all possible it is better not to. RTFDS.
- ⁷ It is permissible to pull up a terminal with internal pull-down, or vice versa, and may sometimes be necessary, but this will (very slightly) increase the system’s current consumption.

- ⁸ Bryant, James. [“Caveat Emptor.”](#) *Rarely Asked Questions*, Issue 4.

Additional Related Articles:

- Bryant, James. [“Some Thoughts on the Connection of Unused Pins.”](#)
- Bryant, James. [“How to Make Sense of a Data Sheet.”](#)
- EE-85. [“Recommended Handling of Unused SHARC Pins.”](#) Analog Devices.
- EE-138. [“Recommended Handling of Unused ADSP-21161 Pins.”](#) Analog Devices.



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