Q'n Apps #E61

Q: Can I measure pin-to-pin resistance?

Pin-to-pin resistance measurement for analog pins

Devices with some internal switching or other analog characteristics often require measuring resistance between pins. The technique illustrated in this Q'nApp can be used for regular digital pins also, as well as for single pins resistance test.

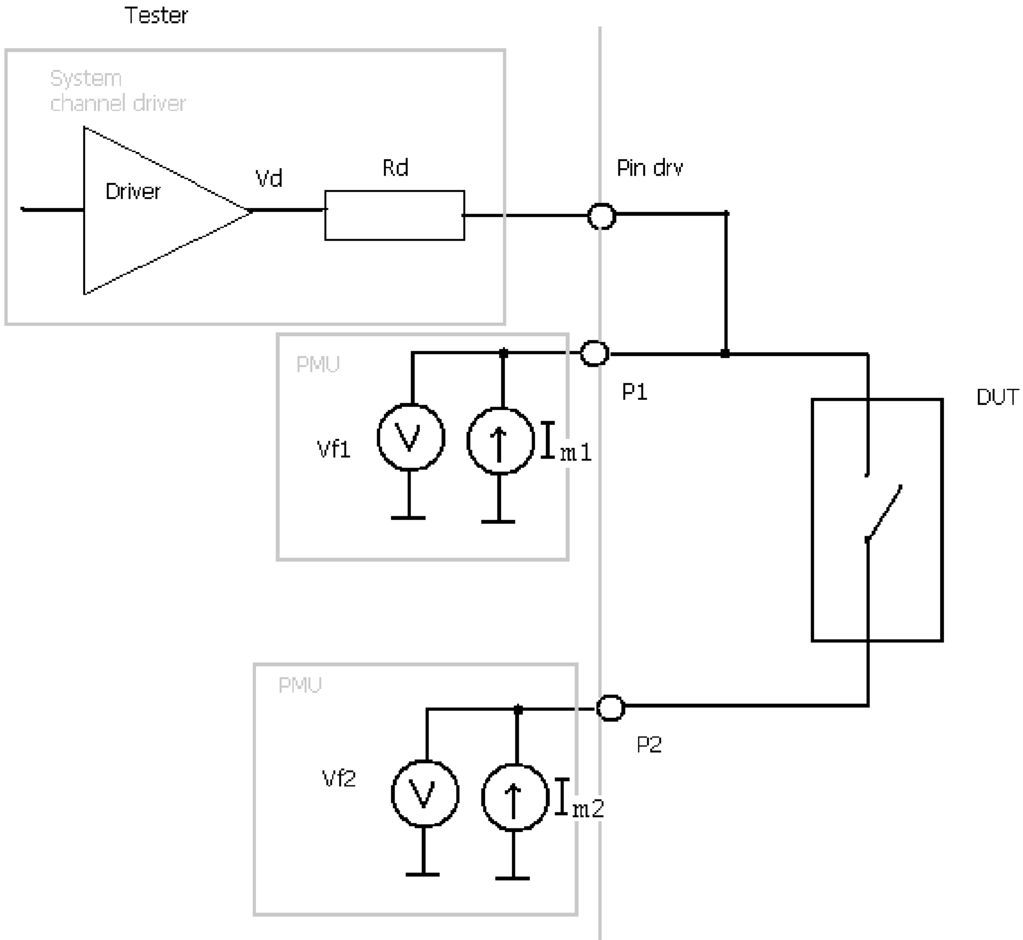
The concept uses drivers to apply voltage on one pin and sink current with the DCPMU on a second pin. By taking current measurements on both pins we can determine the voltage drop between pins. From this we can calculate the pin-to-pin resistance using a simple equation:

$$R_{p1p2} = (V_{p1}-V_{p2})/I_{meas}$$

Where:

P1 and **P2** are two pins between which we will measure resistance
Rp1p2 is the resistance between the P1 and P2 pins
$\mathbf{I_{meas}}$ is the current we measure/sink
$\mathbf{V_{p1}}$ and $\mathbf{V_{p2}}$ are the voltages forced at the pins P1 and P2

Consider the schematic we shall use to illustrate this, and the description that follows:



We use one additional digital pin (Pin drv) to force a programmed voltage to the pin. This pin is in the high-impedance state during all tests except this one. The pin is connected to one of analog pins of the device. During the test we will program some voltage, let's say 4V on this pin, set the analog switch to the open state, enable the driver and make a DC test on pin P1, using ñforce voltage measure currentò (PMU force set to 1V). This measurement will let us compute the exact output resistance for the pin driver from the equation:

$$R_d = (V_d \text{ ï } V_{f1})/I_{m1} \qquad [1]$$

Where:

Rd is the pin driver output impedance
Vd is the programmed driver voltage (4V in this case)
Vf1 is the forced voltage from the PMU on pin P1 (1V in this case)
Im1 is the current measured on pin P1 by the PMU

Now we can run a test pattern to set the DUT so the analog switch is closed and take the same measurement on pin P2, with the same conditions applied.

This time the equation is as follows:

$$R_d + R_{dut} = (V_d \text{ ï } V_{f2})/I_{m2} \qquad [2]$$

ñRdutò is the same as ñRp1p2ò, the resistance between the two DUT pins.

Combining formulas [1] and [2], we have:

$$R_{dut} = (V_d \text{ ï } V_{f2})/I_{m2} - (V_d \text{ ï } V_{f1})/I_{m1} \qquad [3]$$

We can eliminate Vd from the equation by taking two measurements for each pin and calculating the differential value. Let us say that the first ñforce voltage measure currentò event will be with force value of 2V, and the second with ï 2V.
Now the equation will look like this:

$$R_d = (V_{f1}' \text{ ï } V_{f1}'')/(I_{m1}' \text{ ï } I_{m1}'') \qquad [4]$$

The quotation marks above (" and ') signify the first and second voltage force values and the resulting current measurements. And so here is the final equation:

$$R_{dut} = (V_{f2}' \text{ ï } V_{f2}'')/(I_{m2}' \text{ ï } I_{m2}'') - (V_{f1}' \text{ ï } V_{f1}'')/(I_{m1}' \text{ ï } I_{m1}'')$$

The second approach is recommended, since it gives more accurate results. In our experiments using a 64-Ohm resistor, we found the following.

For a single measurement: 57 Ohm
Using the differential measurement method: 64.97 Ohms

We used the 200mA range of the DC PMU with current ranging from 90mA to 18mA. Careful selection for test conditions (so that the 20mA range could be used, for example) should give more accurate results.

To make the measuring process easier, create a small C program that measures and gathers the results, and then uses the differential formula for the resistance measurement.

See Also:
QnApp E45: Pin-to-pin continuity