R8C/35C Group

Measuring MCU Current on the RSK

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Introduction

This document shows how to measure the power consumption of the R8C/35A MCU while using the RSK (Renesas Starter Kit), RSK number RSKR8C35C. Though this document deals specifically with the R8C/35C the basic principles are applicable to all Renesas Starter Kits.

Target Device

R8C/3x Series: R8C/35C Group

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1. Introduction

When evaluating one of the Renesas MCU's, some designers want to be able to confirm datasheet ratings or to measure certain power settings in combinations not specifically spelled out in the Hardware Manual. For these situations, it becomes handy to have the Renesas Starter Kit (RSK) that can provide a platform that can be quickly adapted for all sorts of performance tests.

Designed into the hardware are many ways to change the configuration, to allow or avoid the use of on-board peripherals, using different clock sources, using various communication modes, and in the subject addressed here, in measuring the current used by the MCU.

2. The MCU Current test points

The Renesas Starter Kits all share the ability to disconnect the MCU VCC from the rest of the board's logic power, to allow the user to measure the MCU current consumption independent of the rest of the board. On the RSKR8C35A board, this is done by removing the zero-ohm resistor at R25. The current test points are then available as a 0.1" header at J6, or for larger test points at T1 and T2. Neither the J6 header nor the T1-T2 test points are installed by default, so it is up to the user to choose the preferred connection points for their configuration. For this document, we will use J6 as soldered with a two-pin header. This particular configuration is convenient for installing a plug-in shunt when current measurements are not being taken.

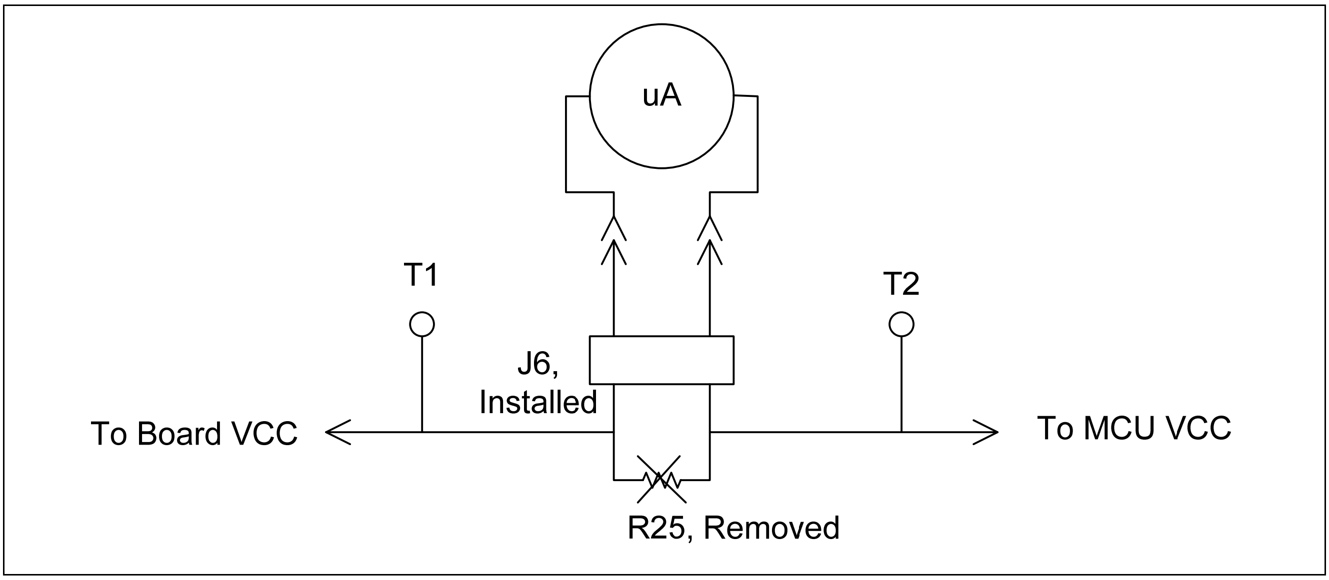

Figure 1. Simplified schematic of MCU current test points

3. Other RSK Loads

While the MCU current can now be measured, there is also another load still present that will be measured by the current meter at J6. The potentiometer at RV1 is connected to Vref, which is connected to MCU VCC. This means that the 10k resistance will be part of the load measured at the test points. This may be a significant current (if VCC is 5V, the current is 5V/10k ohm = 500uA) so, for users wishing to measure current in inactive modes, it may be necessary to remove RV1 to further isolate the MCU current. It is not recommended to disconnect the Vref pin, but only to remove the potentiometer.

4. Configure I/O pins

Unused I/O pins can cause measurable current drain on the MCU if they are allowed to float. They can source current into external loads that may not be accounted for, making the current consumption seem larger than it should. Or, they can provide a path for current to be brought into the MCU, making the current consumption seem less than it actually is.

It is very important, therefore, when doing current measurement tests to account for every pin on the MCU, to be sure that it is not a path for unexpected current flow.

Here are important points to remember:

1. Most unused I/O pins can be set to output LOW level. This prevents the pin from floating or from being a path for either stray output currents, or phantom input currents. Setting as output HIGH is also acceptable. But some pins, noted below, are connected to other circuits on the RSK, so they must be handled differently.
2. LED's connected to VCC with series resistors should not be assumed to be satisfactory pull up resistors for an input pin, as the LED voltage drop may allow the I/O pin to enter an undefined logic state. It is preferred to configure these pins as outputs at HIGH level, to prevent current flow into the LED, and to keep the pin at a clearly defined logic level.
3. Some I/O pins are connected to external logic outputs which can source current into the MCU I/O pin. For these, configure the I/O pin to be an input. Keep the voltage difference between the board VCC and the MCU VCC as small as possible. These pins include: UART receive pins, LIN receive pin and LIN SLP pin. Alternately, they can be completely disconnected by removing the zero ohm resistors in series with these lines into the MCU I/O. Once that is done, the pin can be configured as an output, LOW as with others.

Note: one situation very likely to cause current measurement errors is when an I/O pin is configured as output HIGH and is connected to a voltage source (like a HIGH logic output of another chip). This situation will allow a very low impedance path into the MCU VCC while partially bypassing the VCC pin. Depending on the meter used, this may make the VCC current appear to be much less than it actually is. See the next section for more details on this situation.

5. Current Measurements with Meter

It is very convenient to use a Digital Multi-Meter (DMM) to do the current measurements. These often allow sensitivities down to a microampere or less. One limitation with typical current meters is that they rely on a shunt resistor to provide a voltage drop as current increases. This shunt resistor is usually scaled so that each reading, when at full scale, will have no more than 0.3V burden voltage across the test leads. This seems like an insignificant voltage to worry about, but for the sake of measuring MCU currents, it can be a significant source of error.

The error is due to the fact that in a circuit with multiple power buses, and with connections made between the circuits at I/O pins, it is possible that a 0.03V (a much smaller voltage) drop between the Board power and MCU VCC is enough to begin an I/O pin to conduct current into the MCU VCC through a rail diode or output transistor. The effect is subtle as the effect is small at these low voltages, but when currents of a few microamperes or less are being measured, such stray currents can become large in scale. For this reason, it is recommended to use burden resistors no larger than 100 ohms (to minimize the voltage drop). During measurements, one trick is to change the scale on the meter to verify that the two most significant digits of measurement do not change when the scale is changed (and the internal shunt resistor is changed), this shows that current is not being seriously affected by the burden voltage.

6. Current Measurements with Oscilloscope

The DMM is best suited for static current measurements, where the current value is not changing from moment to moment. However, when trying to find the current consumption during a transition from one mode to another, it is more suitable to use an oscilloscope to make the measurements, in order to view the transition event.

Note: it is very important when doing current measurements with the oscilloscope that the RSK power source be isolated from the oscilloscope ground. Since the scope leads are connected at VCC, large currents can flow on the oscilloscope return line through ground back into the power source if the two are not isolated from one another.

Oscilloscopes can be triggered to capture short duration events, and this feature is handy for capturing the short duration signals of operating mode transitions, such as when the MCU enters active mode from wait mode. If desired, the MCU can be programmed to provide the trigger signals on I/O pins necessary to synchronize the events with the captured current waveform.

In order to capture the current waveform on the oscilloscope it is necessary to use a shunt resistor. Just like the ammeter, a value of 100 ohms is a good value for the lower current levels we will be looking at in the low power modes. Besides the resistor, it may be necessary to add some low-pass filtering, as the MCU current, at this low level, will vary with clock edges, and is easier to view the current if the fast clocks themselves are averaged out, leaving the somewhat slower power transition signals visible. For this, it is necessary to choose a parallel capacitor to place across the shunt resistor to provide the right amount of filtering. The best value to choose may be found by calculation or trial and error. For this discussion, we used a shunt resistor of 100 ohms, and a parallel capacitor of 4.7uF.

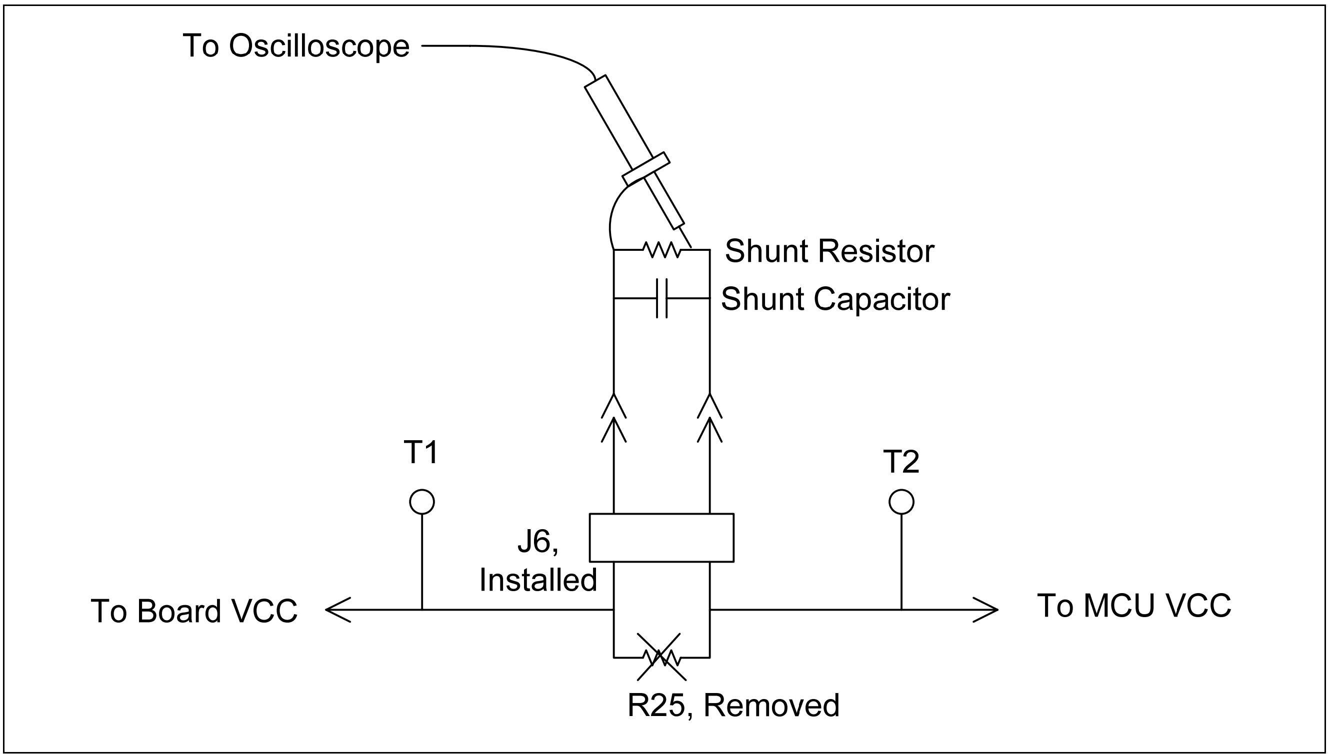

Figure 2. Configuration of current measurement with oscilloscope

The shunt resistor/capacitor combination is connected to the RSK at the same current test points as the DMM. If using a pin header at J6, then a mating connector with the shunt and capacitor can be made to fit this, and also to provide the connection points for the oscilloscope test leads.

The value of resistor/capacitor used in these measurements was 100 ohms and 4.7uF. The cutoff frequency of this combination is: Fco(Hz) = 1/(2*PI*R*C) = 1/(6.28*100*4.7e-6) = 338 Hz. The oscilloscope input probe was at 1x.

The vertical scaling on the oscilloscope has to be calculated based on the shunt resistor used. The current measured is simply the voltage measured divided by the shunt resistor. To make it convenient to make a visual reference, here is reference of vertical voltage scales versus the current scales using the 100 ohm shunt resistor:

Voltage Scale, Current Scale
20mV/Div, 200uA/Div
50mV/Div, 500uA/Div
100mV/Div, 1mA/Div
200mV/Div, 2mA/Div
500mV/Div, 5mA/Div

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Nov.15.10	—	Initial Release

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.
   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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