

## Technical Tips to use back up switch over circuit of R2051/61/62

R2051/61/62 contains Back up switch over circuit that is usually necessary to use with Real time clock IC to change Main Power source , normally CPU VDD, and Back up power source according to needs. In this document some technical tips is described.

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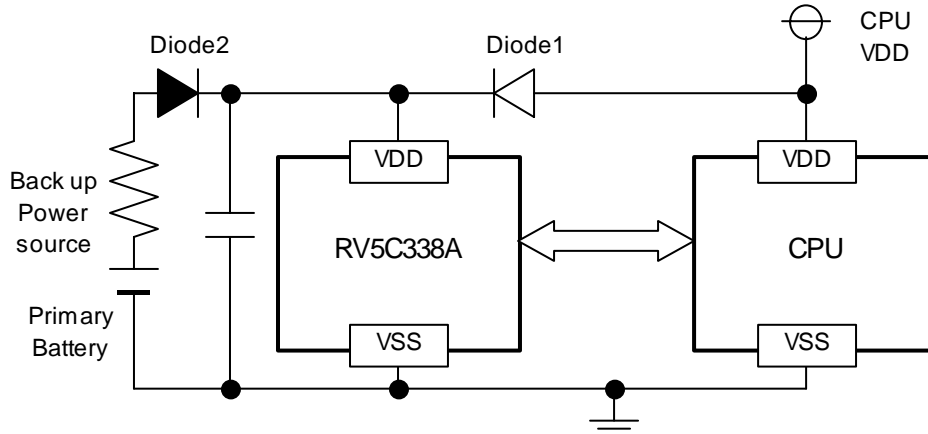
### < Objects to be described from our RTC range >

In this document following Real Time Clock in the list is object to be described

	TSSOP10G	FFP12	SSOP16
I <sup>2</sup> C Bus	R2051T01	R2051Kxx	R2051Sxx
3 wire serial Interface		R2061Kxx R2062Kxx	R2061Sxx

### < General Back up switch over circuit & a limit of it >

Picture 1 shows general Back up switch over circuit. It consists of external Diode OR circuit.



Picture1 : Back up switch over circuit with Diode OR Circuit

While level of CPU VDD is normal operating range,  $(\text{CPU VDD}) - (V_f \text{ of Diode1}) > (\text{Back up power source}) - (V_f \text{ of Diode2})$ , CPU VDD is the power source for RV5C338A VDD and when level of CPU VDD is decreased less than the level of  $(\text{CPU VDD}) - (V_f \text{ of Diode1}) < (\text{Back up power source}) - (V_f \text{ of Diode2})$  then Primary Battery is the power source for RV5C338A VDD to back up the RTC.

It is simple solution however it is required to consider following point to design or to chose the components.

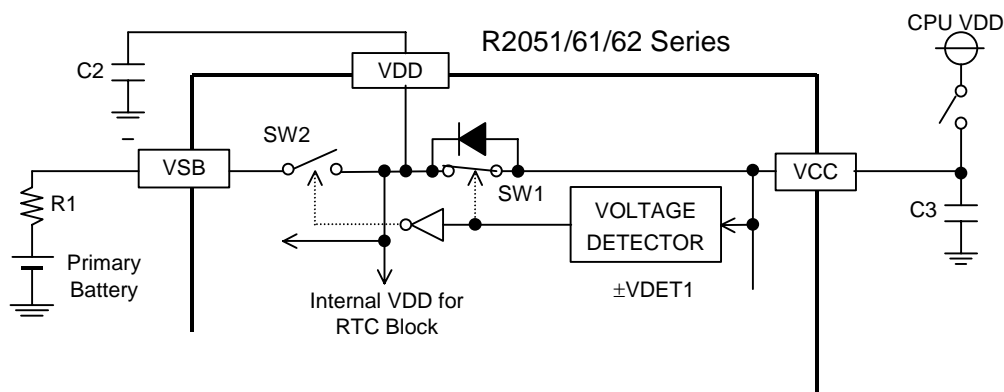
- (1) Forward Voltage ( $V_f$ ) of Diode1 should be less than 0.3V
  - (2) Reverse current ( $I_r$ ) of Diode1 should be small enough
- \*Sufficiently small enough than time keeping power consumption of RTC

However generally it is difficult to find sufficient Diode that has enough specification to fit the condition of above (1)&(2). Normally schottkey type diode is used as it has small  $V_f$ . But normally if  $V_f$  is smaller then  $I_r$  is bigger. So it is very difficult to find sufficient diode. Even if you could find the sufficient diode in specification at normal temperature,  $I_r$  increases an exponential way in high temperature then back up time is sometimes quite short in high temperature condition.

Moreover this Diode OR circuit can not be used when level of CPU VDD is less than Back up battery VDD level and for this case more complicated circuit is required.

< Back up switch over circuit of R2051/61/62>

Back up switch over circuit of R2051/61/62 is shown as Picture 2 below.



Picture2 : Back up switch over circuit of R2051/61/62  
(R2062 does not have VSB pin)

Voltage Detector watches VCC level and when VCC is higher than  $-V_{DET1}$  level, it sets SW1 to be ON & SW2 to be OFF then VCC is the power source for Internal VDD for RTC Block. When VCC decreases less than  $-V_{DET1}$  level, SW1 is changed to be OFF and SW2 is changed to be ON then Primary Battery (VSB) is the power source for Internal VDD for RTC Block. Back up switch over circuit of R2051/61 has following advantage to the general circuit using Diode OR circuit.

- (1) Voltage loss between VCC and VDD is smaller. As this circuit uses MOS switch for switch over circuit. Especially in the condition of Lower consumption current is effective.
- (2) As this circuit uses MOS switch for switch over circuit, in most of the case  $I_r$  is smaller than the one using Schottkey Diode. And also  $I_r$  of MOS switch is more stable in high temperature than the one of Schottkey Diode.
- (3) Even when level of CPU VDD is less than Back up battery VDD level it is possible to use simple circuit as change over is controlled by voltage detector that watches the level of VCC. Then it is possible to use higher voltage for Back up battery ( Capacitor ) to have longer back up time.

To avoid any mistake it is required to consider following point.

- (1) There is a period both SW1&SW2 is OFF when they are changing. Then it is required to have external capacitor (C2) as shown in picture 2 to avoid voltage drop. The period is quite short (several  $\mu s$ ) and consumption current of RTC is also quite small (0.4 $\mu A$ ) so 0.1 $\mu F$  of C2 is enough to avoid problem.
- (2) If there is a big voltage difference between VCC and VDD then VDD is swinging a lot when SW1 and SW2 is changed. Because of this reason R1 in the picture2 is necessary. R1 is necessary in the general Diode OR circuit by safety reason as well.
- (3) When RTC should use the power source from back up battery VCC level should be less than the level of  $+V_{DET1}$ . Because voltage detector made switch1&2 to be ON or OFF by watching the VCC level. Detail description on this point will be done later.

(4) Internal MOS has not enough low ON resistance to support heavy load then it is not possible to have heavy load from VDD pin. If possible it is perfect to connect SRAM to VDD pin however it is not possible to have such heavy load.

\* Terms of -VDET1/+VDET1 in this document means detecting voltage / Release voltage of voltage detector. Please refer to product datasheet for more information.

< Basic technical Tips>

Usually following devices can be used as a back up power source

/ Primary Battery

/ Rechargeable Battery

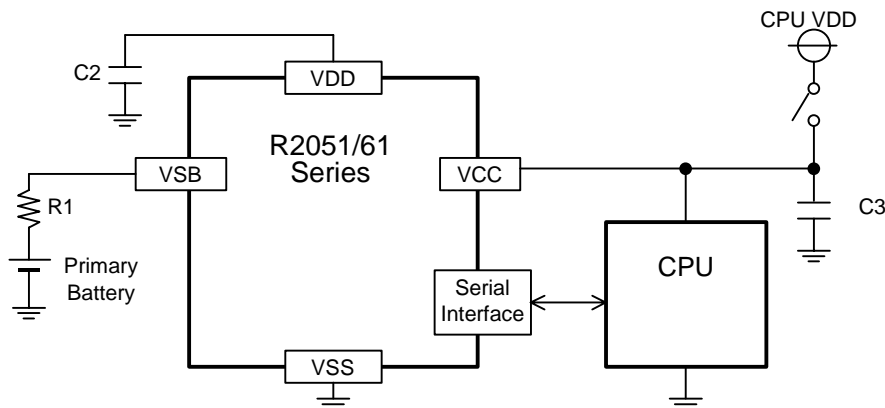
/ Big capacitance (ex.0.2F) Capacitor (Double Layer Capacitor , Polyacene Capacitor etc.)

/ Normal (ex.22 $\mu$ F) Capacitor (Aluminum electrolytic Capacitor , etc. )

Followings are the some notice to use each back up device with R2051/61.

(1) Use Primary Battery (R2062 not supported)

Following picture 3 shows example for Back up circuit using Primary Battery



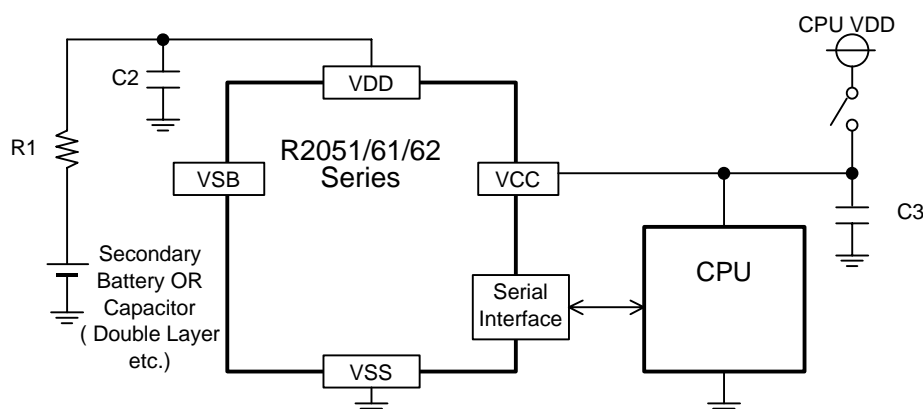
Picture 3 : Example for Back up circuit using Primary Battery

As described before it is required to have approximately 0.1 $\mu$ F of C2.

Min.1k $\Omega$  of R1 is also required for this circuit. Additional resistance for R1 might be added according to the specification of Primary Battery. In many case it is required to consider additional back up way for replace the Primary Battery. The way will be described in the item <Advanced technical Tips> later.

(2) Use Rechargeable Battery or Big capacitance Capacitor

There are two types of circuit to use Rechargeable Battery or Big capacitance Capacitor for instance Double Layer Capacitor or Polyacene Capacitor. Picture 4 shows the 1<sup>st</sup> case of Example for Back up circuit using Secondary Battery OR Capacitor ( Double Layer etc.) especially when CPU VDD = Back up voltage.



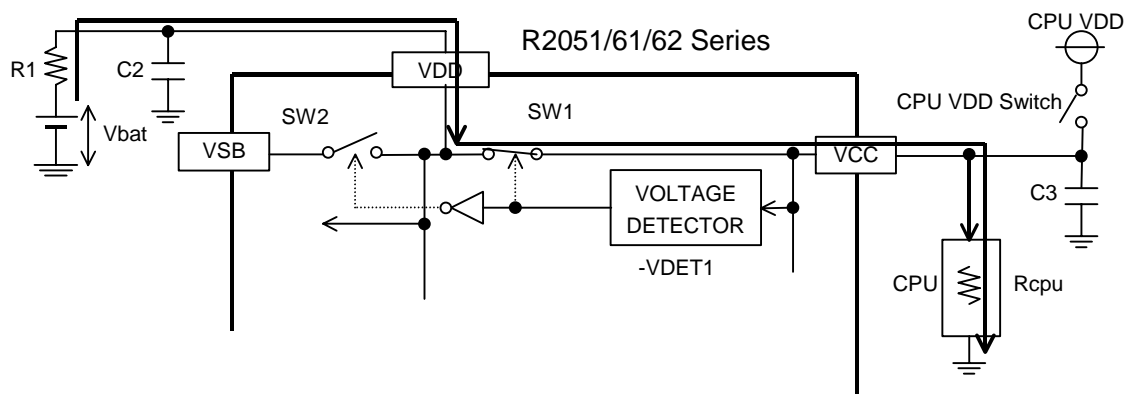
Picture 4 : Example for Back up circuit using Secondary Battery OR Capacitor ( Double Layer etc.) especially when CPU VDD = Back up voltage

While charging Back up power source charging current flow from CPU VDD via VCC pin & VDD pin to Rechargeable battery or Capacitor. It is required to select carefully the value of R1 for this circuit.

Picture 5 shows Discharge current route from Back up battery after switch OFF CPU VDD switch. When Rechargeable battery or big capacitance capacitor is used on VDD pin like in this circuit ,after switch off the CPU VDD Switch discharge current flow from the battery to CPU as shown by heavy arrow line. If value of R1 is quite smaller than impedance of CPU ( $R_{cpu}$ ) VCC Voltage might keep higher than level of  $-VDET$  that makes SW1 to be off, then SW1 might stay to be on. Therefore R1 is limited by following formula.

$$R1 > R_{cpu} \times (V_{bat} - (-VDET1)) / (-VDET1)$$

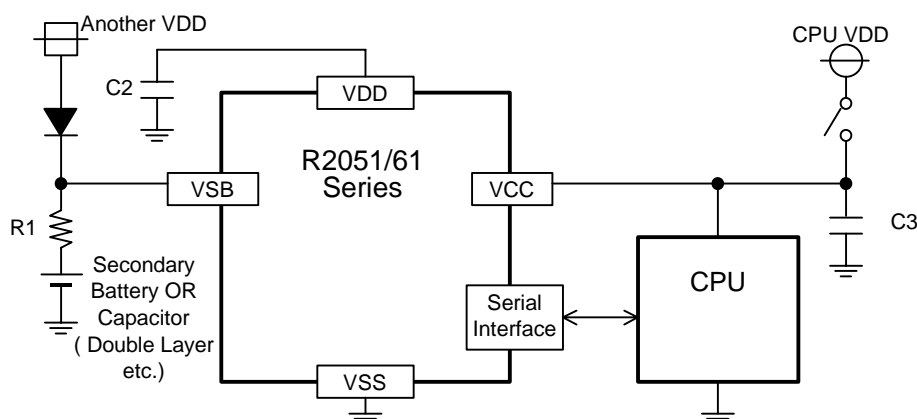
And also sometimes R1 is limited by the specification of back up device. Please refer to specification from Back up device manufacture as well.



Picture 5 : Discharge current route from Back up battery after switch OFF CPU VDD switch

Picture 6 shows example for Back up circuit using Secondary Battery OR Capacitor ( Double Layer etc.) especially when CPU VDD is not equal to Back up voltage

Many of the rechargeable battery has limited maximum charging voltage therefore CPU VDD and charging voltage for Back up battery is not always the same. Even the limit for Big capacitance Capacitor is lax than rechargeable battery it is preferable to charge as high voltage as possible. In this case this circuit is used.



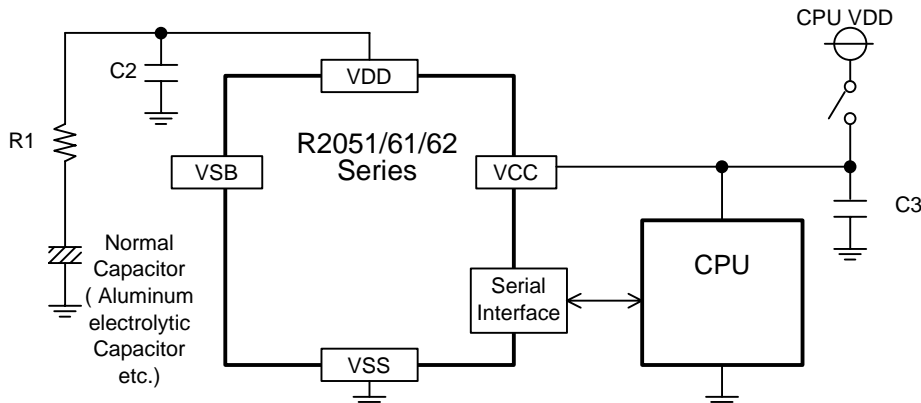
Picture 6 : Example for Back up circuit using Secondary Battery OR Capacitor ( Double Layer etc.) especially when CPU VDD ≠ Back up voltage

By discrete products it is complicated and not easy to make back up switch over circuit having higher charging voltage for back up device than CPU VDD level. On the other hand it is easy to make it by back up switch over circuit of R2051/61.

(3) Use Normal (ex.22 $\mu$ F) Capacitor (Aluminum electrolytic Capacitor , etc. )

Back up time of several minutes is enough for some of the system. In this case it is possible to use Normal (ex.22 $\mu$ F) Capacitor (Aluminum electrolytic Capacitor , etc. ) at back up device.

Picture 7 shows Example for Back up circuit using Normal Capacitor ( Aluminum electrolytic Capacitor etc.)

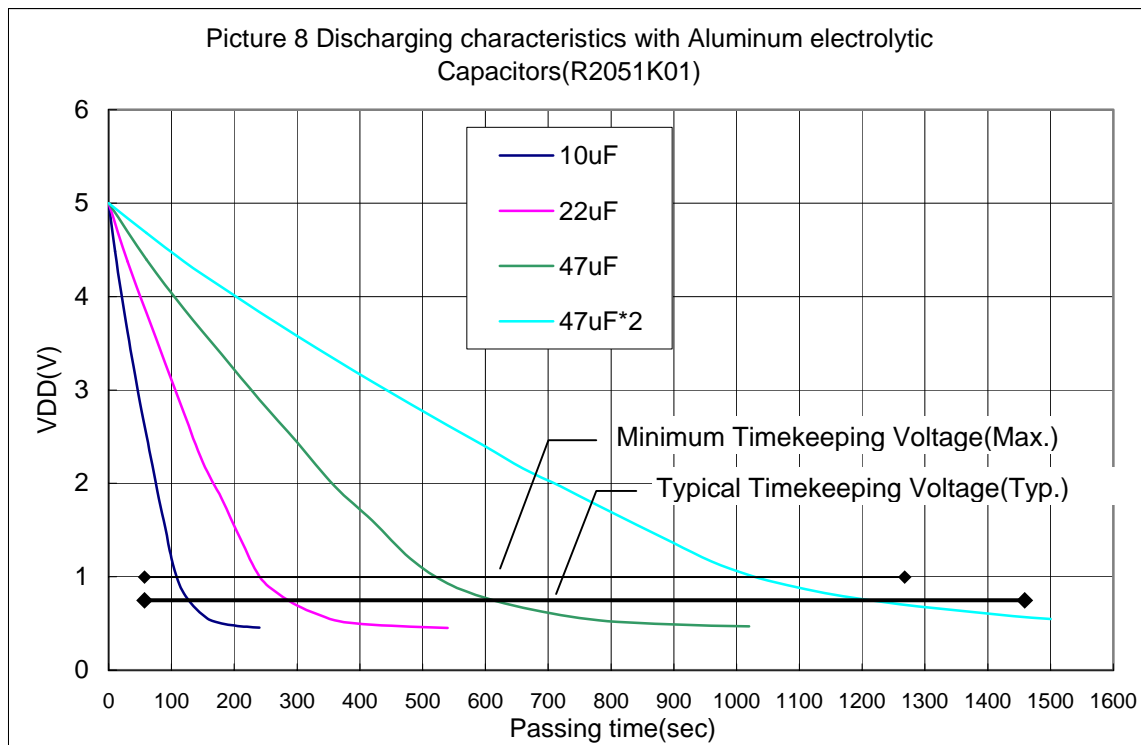


Picture 7 : Example for Back up circuit using Normal Capacitor ( Aluminum electrolytic Capacitor etc.)

R1 at Picture 7 makes back up time longer as it is avoid to immediate discharge from VDD via VCC even when CPU VDD decreased a little. There is an advantage especially in the case of the difference between CPU VDD and -VDET exist. And also it is recommended to have approximately 1k $\Omega$  of R1 resistor for the purpose to protect internal circuit of IC itself.

Of course circuit like picture 6 is also possible for Normal Capacitor.

Following picture 8 shows typical discharging characteristics of R2051/61/62 series measured with Aluminum electrolytic capacitors



To summarize picture 8 typical back up time is as follows.

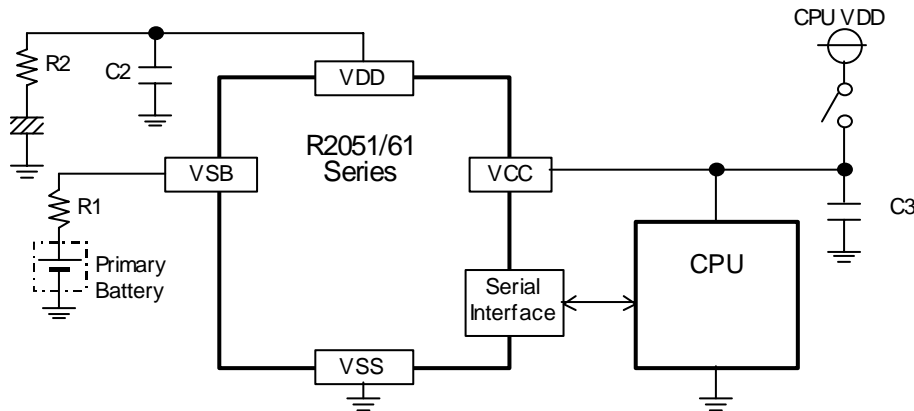
	10 $\mu$ F	22 $\mu$ F	47 $\mu$ F	47 $\mu$ F $\times$ 2
Back up from 3V	80sec	180sec	510sec	770sec
Back up from 5V	120sec	290sec	610sec	1210sec

<Advanced technical Tips>

It is possible to make various kind of back up circuit in addition to the circuit introduced in basic technical Tips by using VDD,VCC&VSB of R2051/61 series. Some application circuit is described in this item.

(1) Additional back up circuit for replace primary back up battery (R2062 not supported)

Sometimes it is requested to consider to have additional back up circuit for replace primary back up battery. Picture 9 shows example for Back up circuit required to replace the Primary Battery for the replacement back up time is around several minutes to less than 20 minutes.

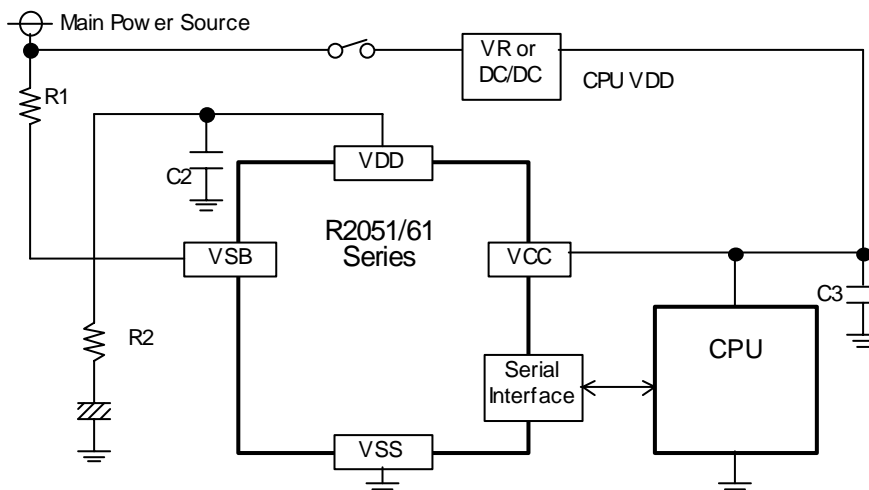


Picture 9 : Example for Back up circuit required to replace the Primary Battery

It is requested to have a diode between R1 and VSB, if there is an expected short problem for pulse terminal and minus terminal of battery holder when replacing the primary battery.

(2) To reduce consumption current at stand by mode (R2062 not supported)

Sometimes it is requested to back up only RTC at Stand by mode if the system has main power switch. It is also easy to make the circuit using back up switch over circuit of R2051/61.

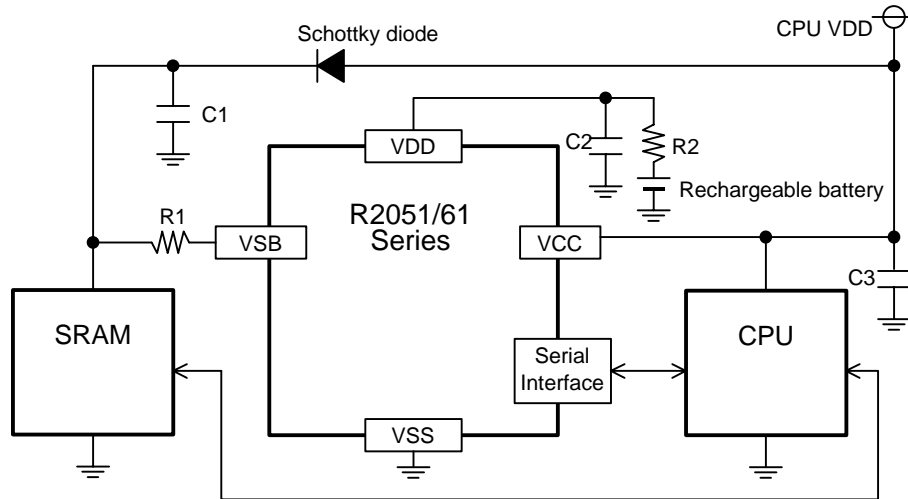


Picture 10 : Example for Back up circuit to reduce consumption current at stand by mode

In this case complicated circuit is requested to make the back up circuit with discrete product as normally voltage of Main power source is higher than CPU VDD. However it is no problem for R2051/61 to have the condition of  $VSB > VCC$  then circuit can be quite simple.

(3) Back up for SRAM (R2062 not supported)

As described before it is not possible to connect heavy load from VDD pin by lack of internal MOS switch ability. Then Picture 11 shows example for Back up circuit to back up SRAM



Picture 11 : Example for Back up circuit to back up SRAM

Rechargeable battery can be connected to VSB side in stead.

<Notice>

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