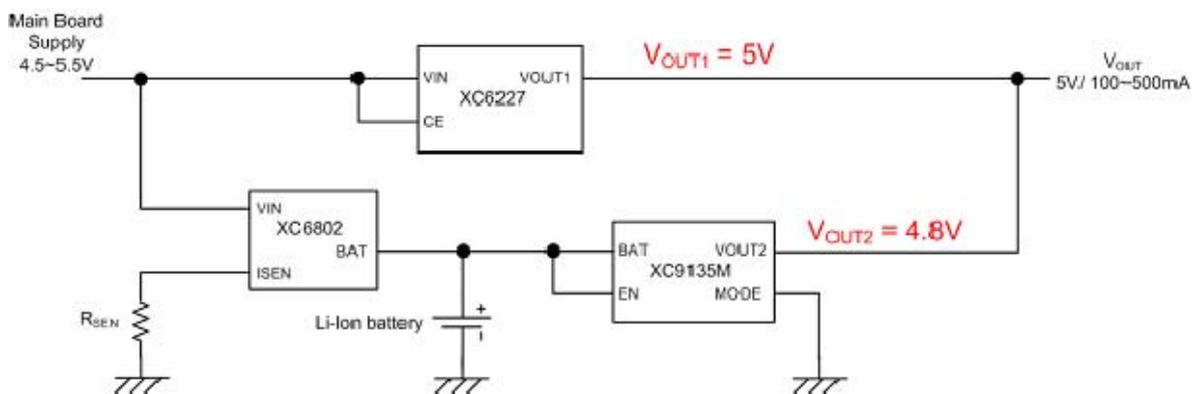


This new document will present a way to parallel two supplies (the main board supply and a Li-Ion battery) in order to power a single output. While the Li-Ion battery is not in use, it will get recharged by sampling a small portion of the current from the main board supply. The reader is advised to review TIP No.28 before going any further, because this new document further expands on the concept introduced in TIP No.28. Please note that the only IC that should be recommended with this new circuit configuration is the XC9135M (Output voltage internally set, no CL discharge function, UVLO –Under Voltage Lock Out- threshold can be factory-set up to 3.0V).

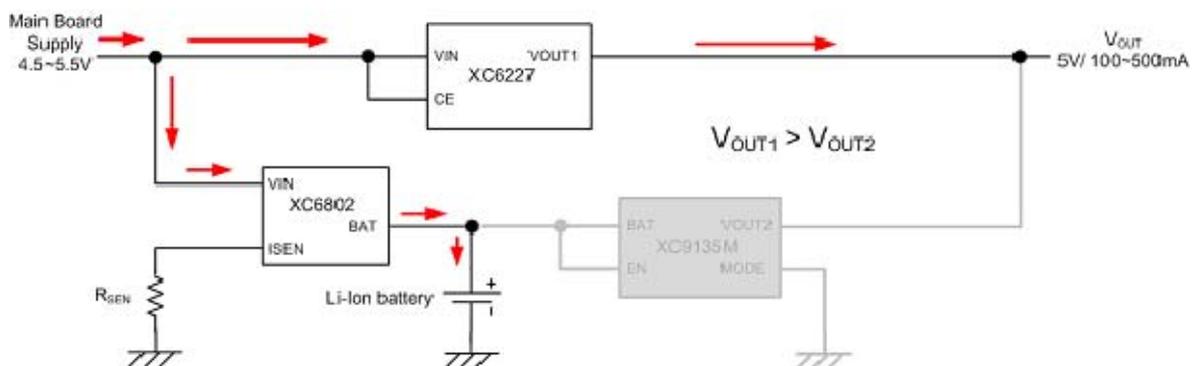
The below circuit diagram shows the proposed solution. As you can see, the input power is split between the XC6227 LDO voltage regulator (with built-in reverse current protection) and the XC6802 Li-Ion battery charger. A XC9135M synchronous step-up DC/DC converter is connected after the Li-Ion battery, and the XC9135M output is paralleled with the XC6227 output. The XC6227, XC6802 and XC9135M are all Torex IC's. As detailed within TIP No.28, the MODE pin of the XC9135M must be set to 'Low'.

You may have noticed that the EN and BAT pins of the XC9135M are connected together. This permits the circuit to still supply current to its output even after the main board supply is disconnected, without requiring an additional logic signal to control the EN pin. But the compromise is that the XC9135M will only stop operating when its UVLO function detects that the Li-Ion battery voltage is too low. If you want to keep more control over the enabling/disabling of the XC9135M (especially when the main board supply is disconnected), and if you can afford to use one additional logic signal, this signal can control the EN pin of the XC9135M.



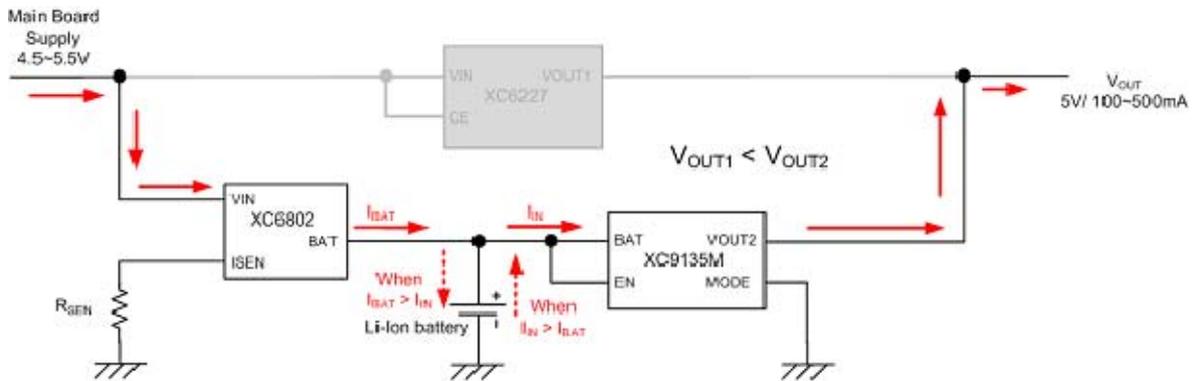
The operation of the above circuit can be split into 3 main cases.

- Case A: The main board supply is connected and  $V_{OUT1}$  is higher than  $V_{OUT2}$ .



In this case, the flow of input current gets split between two paths. As will be explained in the "KEY DESIGN POINTS" chapter, the amount of current that flows towards the XC6802 can be set via  $R_{SEN}$ . Since the XC9135M detects that its set voltage ( $V_{OUT2}$ ) is lower than the voltage of the load circuit ( $V_{OUT} = V_{OUT1}$  here), the XC9135M stops supplying any current.

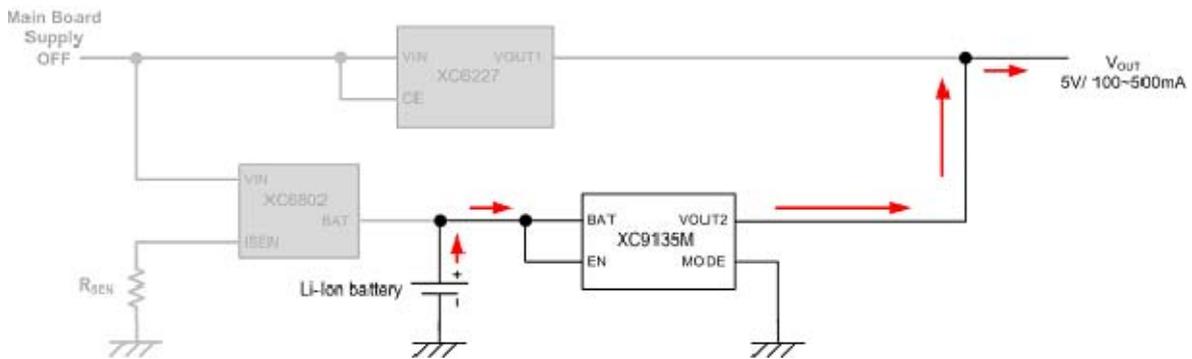
- Case B: The main board supply is connected and  $V_{OUT1}$  is lower than  $V_{OUT2}$ .



In order to highlight one of the key features of the circuit, let's assume that "Case B" occurs after "Case A". In other terms, the voltage of the main board supply (let's call it  $V_{IN}$ ) starts dropping well below 5V, down to a point where the XC6227 output simply follows its input:  $V_{OUT} = V_{OUT1} = V_{IN} - (V_{DROPOUT})_{XC6227}$ . At one point,  $V_{OUT}$  drops below  $V_{OUT2}$ . This is detected by the XC9135M, which starts immediately to supply current to the output. Indeed, one of the keys features of the circuit is that the XC9135M isn't disabled under the conditions of "Case A", so the XC9135M doesn't have to execute what would otherwise be a lengthy soft-start procedure before supplying current.

At the same time, the reverse current protection built inside the XC6227 prevents any reverse current from flowing through this IC.

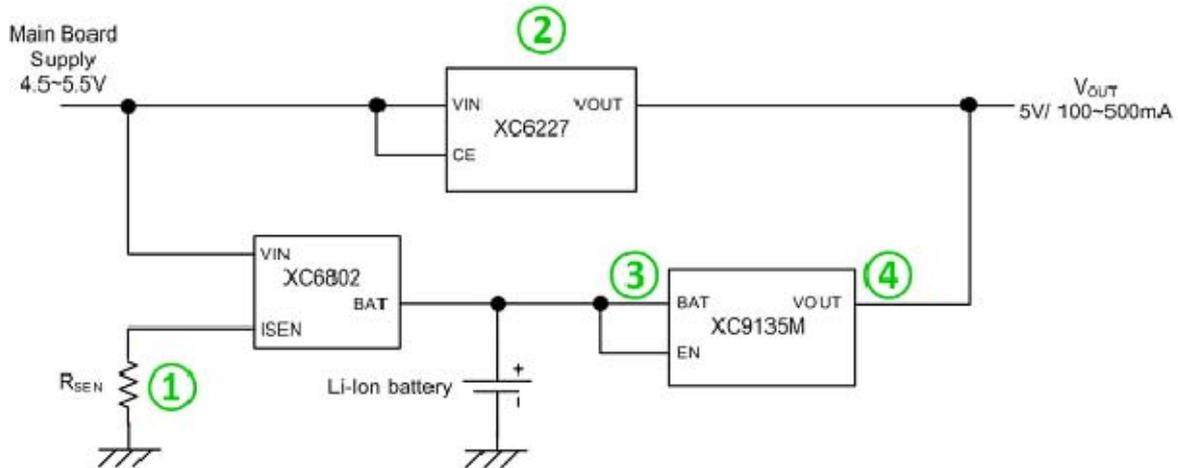
- Case C: The main board supply is off or disconnected.



In this case, both the XC6802 and the XC6227 are off. The output current is supplied by the XC9135M, which is itself powered by the Li-Ion battery. Despite being off, the XC6227 and XC6802 both make sure that there is hardly any leakage current that enters via their VOUT and BAT pins respectively. In particular, the fact that the XC6802 includes a reverse current protection circuit is not very well known, but it comes in handy here.

**KEY DESIGN POINTS**

We will now delve into further details by explaining how some external components and IC's have been selected.



①: There is a compromise to reach regarding the maximum charging current set by  $R_{SEN}$ :

On the one hand, if this max charging current is too big, the XC6802 will pull too much current from the main board supply, so there will be too little current available for the XC6227 to supply to the output circuit. For example, if the main board supply provides up to 400mA and the output of the circuit requires up to 300mA,  $R_{SEN}$  should be set so that the maximum charging current of the XC6802 is 100mA. We must never forget that when both the XC6802 and the output circuit request current, the demand from the output circuit should always take priority.

On the other hand, if the max charging current is too small, it will take too long for the XC6802 to recharge the Li-Ion battery.

On the above discussion, since the XC6802 only consumes about 15 $\mu$ A, we have logically assumed that the current subtracted from the main board supply by the XC6802 (the current reaching the VIN pin of the XC6802) is roughly the same as the charging current leaving the XC6802 via its BAT pin.

②: The selected LDO should exhibit both a low dropout voltage and a highly accurate output voltage. Both parameters are required for the same reason: you don't want the XC9135M to operate too often, or else it would drain the Li-Ion battery unnecessarily. Thus, by using an LDO with low dropout voltage and high  $V_{OUT}$  accuracy, you can make sure that, as long as the input voltage is not too low, the output voltage of the LDO will remain sufficiently high to guarantee that the LDO (not the XC9135M) is supplying the current to the output of the circuit.

③: The XC9135M needs to include an UVLO function. Indeed, consider the case when the main board supply has been removed (this corresponds to case C). The XC6227 will stop operating, but the XC9135M will take over and supply the output of the circuit until the Li-Ion battery is fully drained. By using the XC9135M which includes an UVLO function whose threshold value can be selected on demand, one can make sure that the XC9135M stops operating when the Li-Ion battery voltage drops below 2.9V, for example.

④: The output voltage of the XC9135M needs to be internally set in order to further improve its accuracy compared with adjustable output step-up DC/DC's such as the XC9131 series. By reducing the tolerance on the  $V_{OUT}$  of the step-up DC/DC, one makes sure that there aren't any samples whose set output voltage is too high and causes the step-up DC/DC to supply the output current more often than it should.