cap-XX APPLICATION BRIEF 1014

Powering GPRS/GSM Devices on Mini PCI Cards with cap-XX Supercapacitors

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Outline

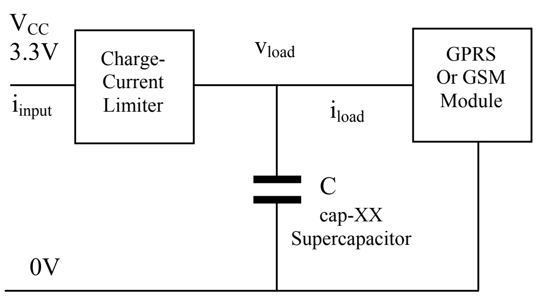
GPRS and GSM modems are now being designed into Mini PCI cards for use in notebook computers. However, the specification limits the current drain of the card to much less than a typical transmitter requires. This application brief describes a solution to this problem, using a cap-XX supercapacitor to power the transmitter without exceeding the maximum input current requirement. This improves the efficiency, while reducing costs compared with a solution using tantalum capacitors with a DC-DC converter.

The Problem

The Mini PCI specification limits the total power drawn by a card to 2W, after initialisation. Power supplies are 3.3V, 5V and 3.3VAUX, which is optional. The main supply for logic is normally the 3.3V rail. The maximum permitted load on the 5V supply is 100mA and that on the 3.3VAUX, if present, varies between 5mA and 375mA, depending on the power state of the card. Therefore, a GPRS or GSM transmitter module typically uses the 3.3V supply. If all the card's power were available from the 3.3V supply, then 606mA would be the maximum current available, assuming the voltage did not droop. In practice, the current must be less than this, as there may also be power drawn from the 5V rail and, possibly, the 3.3VAUX rail. Most transmitters need 1.5A to 2A to transmit at full power at 3.3V. When transmitting in class 8 using one of eight 577µs time slots, the pulse duration is 0.577ms and the period 4.616ms. Clearly, the card cannot operate within the specification without special design measures.

The cap-XX Solution

The diagram below shows a typical design using a cap-XX supercapacitor that solves the problem of delivering the power needed by a GPRS/GSM transmitter, while keeping the current drawn from the Mini PCI interface within specification.



The cap-XX supercapacitor has high C and low ESR (equivalent series resistance), so it delivers large current pulses without much change in load voltage. Because the ripple voltage on the load is small, this load-leveling effect means current drawn from the supply (the host device) during the load pulses can be less than the maximum allowed by the Mini PCI specification. The most important criterion in selecting the supercapacitor is low ESR, because ESR typically contributes most to voltage ripple in high-C supercapacitors.

At power-up, the supercapacitor is usually in a discharged state. To prevent the supercapacitor's charging current from overloading the host, a simple current-limit circuit is used, as shown above. For further information, please refer to Application Note 1002, *Start-Up Current-Limiters for Supercapacitors in PDAs and Other Portable Devices*, from cap-XX, available as a free download from the cap-XX web site.

The Benefits

The low-ESR cap-XX supercapacitor enables a transmitter to operate even though its current drain would usually exceed the value allowed by the Mini PCI specification. This is done with virtually 100% efficiency, instead of the lower efficiency of a DC-DC converter, and the supercapacitor does not generate EMI. The amount of energy that the host can deliver in a typical pulse period can be compared with the energy required by the load by performing a simple energy balance, as illustrated below.

If the load has a duty cycle of D (where $0<D\leq1$) and the load current has a continuous component of i_{steady} and a pulse of i_{peak} (in addition to the steady current), then the average power drawn during one cycle is

$$P_{ave} = V_{CC}(i_{steady} + D\cdot i_{peak})$$

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The maximum average power that may be drawn from the supply is given by

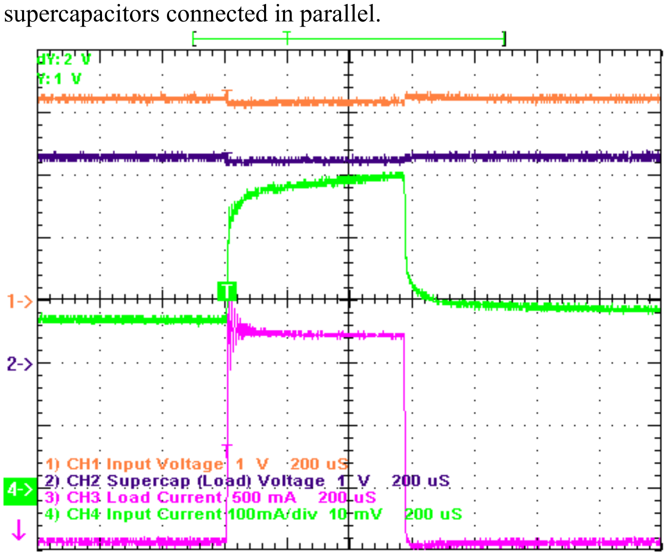
$$P_{ave,max} = V_{CC} \cdot i_{max}$$

where i_{max} is given by the Mini PCI specification as 0.606A, if all power is drawn from the 3.3V rail. In general, the power available on the 3.3V rail will be less than this. P_{ave} must be less than $P_{ave,max}$ for the load to function. Combining the above equations, we need the following:

$$i_{steady} + D \cdot i_{peak} < i_{max}$$

This equation is true for an ideal, infinite capacitor, so some margin must be allowed for voltage ripple in a real device. ***Example:*** Is it possible to run a transmitter in class 8 mode on a Mini PCI card, using 1 slot out of 8 (12.5% duty cycle), if it draws 100mA continuously plus 1.9A peak pulse transmission current? ***Answer:*** $i_{steady} + D \cdot i_{peak} = 0.1 + 0.125 \cdot 1.9 \text{ A} \approx 0.34 \text{ A}$, which is well under the 0.606A limit. This ignores losses, but gives an approximate magnitude of the current that will be drawn from the source when using a cap-XX supercapacitor.

Running a simple simulation can also be helpful in verifying that a load will function successfully. Spreadsheets published by cap-XX on its web site enable one to simulate pulsed loads powered by sources with supercapacitors connected in parallel.



The oscilloscope image shows the traces from a test with a cap-XX supercapacitor. This was a 0.25F, 40mΩ device, type GS204. (Smaller devices are also available.) The source voltage (V_{CC}) was modeled with a 3.3V supply and 200mΩ source impedance. A 33Ω resistor was used to create the 100mA continuous load, and an electronic load imposed a 1.65A pulse for 0.577ms every 4.616ms, to simulate a class 8 (1-slot) transmission. The traces (top to bottom) are source voltage, load voltage, current drawn from host and current drawn by the GPRS/GSM module. (Zero for CH3 is the bottom graticule). Note that the host current reaches only about 500mA. It is higher than the value predicted above (when ignoring resistances), but this is to be expected when taking source resistance and supercapacitor ESR into account. If additional headroom was required in a real application, or if the transmitter drew a higher current, one of the cap-XX supercapacitors with a lower ESR (or a custom-designed type) would be used. When simulating this example with the cap-XX spreadsheet, the source current did not exceed the specified value. Both testing and simulation should be performed, to confirm that the design meets the specifications.

The table below contains examples of cap-XX supercapacitors that would work in the above example without exceeding the 0.606A limit, with the maximum load currents shown. Two devices in series are required when using those with 2.3V ratings. (Contact cap-XX for information on voltage balancing.) Besides the standard devices, cap-XX is able to manufacture products to custom designs as well, when required.

Max i_{load}, A	C, Farads	ESR, mΩ	Voltage, V	Footprint, mm	Thickness, mm	Type No.
1.75	0.45	24	4.5	39 x 17	3.9	GS205
1.75	0.95	12	2.3	39 x 17	1.91	GS105 (2 req'd)
1.65	0.35	32	4.5	28.5 x 17	4.63	GW210
1.65	0.65	16	2.3	28.5 x 17	2.28	GW110 (2 req'd)

Further Information:

cap-XX will be pleased to supply detailed data and design information. For further details, please use the contact information listed at the foot of this page.

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