Fig. 2. Input pulse current.

Fig. 3. Output inductor ripple current.
We thus conclude that the buck-boost converter draws spikes of input current (i.e., with sharp edges). That produces a high dV/dt — and therefore lots of noise originating at the input.

The only exception is the boost, in which the input is in series with the inductor, and therefore the input current waveform is a slowly rising and falling ramp (no "sharp edges"). This makes the boost topology reasonably insensitive to input decoupling (no significant dV/dt on input side).

Therefore, providing effective input decoupling (for the power stage) is a very important goal of good PCB layout — especially for the Buck and the Buck-Boost.
Ground pins of the IC.
- Ceramic capacitors placed very close to the IC -- right next to the supply and output terminals.
- Prevent noise from initializing the IC and causing malfunction. This is usually provided in the IC's design specification.
- Draw spikes of current to drive the Mosfet switches, need good input decoupling section.
- Irrespective of the topology, the IC control sections (and switch drivers -- which is the power stage) should be visualized as dual requirements.
- In general, the decoupling requirements at the input of a power converter.
The second generation SIMPLE SWITCHER (buck) ICs (LM259X) use a BJT.

- Abnormal situations like overloads and output shorts, especially under enough stray inductance to cause the IC to malfunction, especially under close, but on the other side of the PCB -- i.e., the interfering wire apparently the reported anomalous behavior even if the ceramic decoupling capacitor was very close, but on the other side of the PCB -- i.e., the interfering wire apparently was very close, but on the other side of the PCB -- i.e., the interfering wire apparently.

- Reduce the trace length from SW pin to switching node. In fact, customers have reported anomalous behavior even if the ceramic decoupling capacitor was very close, but on the other side of the PCB -- i.e., the interfering wire apparently.

- PCB layout (the second being the diode, which has to be very close too).

- We therefore always need a 0.1uF to 0.47uF capacitor right next to the pin (especially close), the noise is relatively worse (more "customer complaints" tool).

- Speed (MOSFET as the switch). Therefore, because of the high crossover speed.

- The third generation SIMPLE SWITCHER (buck) family (LM267X) uses a high-bulk cap close to the IC (no ceramic).

- In a buck converter driving a BJT, we can usually get away with a single low-grade.

- Aluminum Electrolyte (in parallel to a low-ESR Ceramic). In a buck converter driving a MOSFET, we need a large "bulk capacitor" (e.g., a low-

For example:
Spec

Customer

\[ L \text{ (choosen) } \leq \text{ V}_{\text{max}} \text{ (\( \frac{dI}{dt} \))} \]

\[ V_{\text{out}} \geq \text{ V}_{\text{Ripple}} \]

Want I - Some

Set I (Ripple) into C = \( \frac{2}{3} \) C

is doing energy storage

Related

1. Inductor Ripple Current and Buck Output Circuit

Effects choice of I?
Useless high oscilillation occurs if not low or very low.

ESL

ESR

Capacitors in switch mode power supply.

Output filter

Energy storage C1

Why?

$\frac{P}{V} = \frac{\text{f}1000}{\text{R}_\text{L}} = \frac{62}{C}$

Why ticks? For f = 100KHz.
The application is specific.
So is the capacitor.
Fig. 6. The wet-tantalum curves show a dramatic rise in ESR at low temperatures. (Data courtesy of NASA.)
Output filters for equivalent ripple.

60mF

Four "lysis" electrolytics
Total 23mF

Extra

Feedback should be taken from before second filter to avoid stability problems.
New Organic Semiconductor Electrolytic Capacitors

ESR, close to a film type...
Use them like conventional electrolytics!

While they look similar to radial-lead aluminum electrolytics, new AFD and AFX Organic Semiconductor Aluminum Electrolytics are a better choice for your next compact high-frequency power applications.

- Much Lower ESR than standard types
- Stable performance over the operating temperature range
- Ripple currents up to 10.1A rms
- Capacitance to 3,300µF
- Competitively priced

AFD and AFX Series Capacitors differ in capacitance ranges covered. They are in stock, for sampling and immediate delivery. Visit www.illcap.com today.
Although the ESL is negligible in most capacitors, some of the same factors that affect ESR also affect ESL.

Following picture illustrates the distributed resistance in the construction of a tantalum capacitor, leading to higher ESR.
Tantalum

Being replaced by niobium

Use caution on input

Low ESR (30-150mohm)

High capacitance

Small size vs C
Voltage derating is specifically recommended when the capacitor may see a large inrush current. For example, a 35V Tantalum capacitor may then be usable only if boost topology, so for example, a 35V Tantalum capacitor, and also the output cap of it.

Even that rating is "hazardous", since 50% derating of the max voltage rating may need to be applied.

Their max rating is typically less than 50V.

Aluminum Electrolytics, however, Tantalum capacitors have a capacitance per unit volume almost 3 times better than Decoupling and the Pitfalls of Tantalum Capacitors.
Polypropylene Film Dielectric

Double-Sided Metallized Polyester Carrier Film

Polypropylene Film Dielectric

Metal Foil
Compare old "Lytics" to Metal Film Capacitors

<table>
<thead>
<tr>
<th>Technology</th>
<th>ESR at 100kHz (mΩ)</th>
<th>Ripple Current (A_rms)</th>
<th>Δ C/C 1 to 100 kHz (%)</th>
<th>Δ C/C at -55°C (%)</th>
<th>Leakage Current (µA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallized Polypropylene</td>
<td>&lt;10</td>
<td>&gt;6</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Aluminum Electrolytic</td>
<td>&gt;100</td>
<td>&lt;0.6</td>
<td>&gt;-25</td>
<td>&gt;-30</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology</th>
<th>ESR(mΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-40°C</td>
</tr>
<tr>
<td>Metallized Polypropylene</td>
<td>12.5</td>
</tr>
<tr>
<td>Aluminum Electrolytic</td>
<td>—</td>
</tr>
</tbody>
</table>

Performance of metallized polypropylene capacitors vs. aluminum electrolytics. Capacitance is 10µF, 450VDC.

Lytics "dry up" over T-T
Lytics are not bipolar or stand reverse voltage
Metal/Film are self-healing on many failures
Inserted tab capacitors use thin (5.5 μm) aluminum foil electrodes conduct current through the capacitors and out through tabs to the load.
Extended foil capacitors use thin (5.5 \( \mu \text{m} \)) aluminum foil electrodes to conduct current through high-current electrodes that are generally soldered to the extended foils on either end of the capacitor section.
Once the fault illustrated in Fig. 9 has been cleared, the capacitor will continue to function with the only measurable damage being a small loss of capacitance.
Limited Suppliers
Small Size
High Capacitance
Very Low ESR (10-50mohm)
Specialty Polymer Aluminum
+3.3 V

L

D

+5V/600mA

C1 10nF

C2 10nF

C3 22μF

C4 10nF

605k

200k

V_{IN \; MAX1790 \; FB}
Freq SS Comp

+5V boost with ceramic capacitor

C11 10nF

C12 10nF

C3 33μF

C4 10nF

605k

200k

V_{IN \; MAX1790 \; FB}
Freq SS Comp

+5V boost with postcap capacitor
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Capacitance value (original)</th>
<th>Nominal dc voltage</th>
<th>r.m.s. current</th>
<th>Max. operating temperature</th>
<th>Overall volume</th>
<th>Inductance</th>
<th>ESR (total)</th>
<th>Surge voltage</th>
<th>Price comparison (caps only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolytic</td>
<td>32.4mF</td>
<td>480V x 2 (800V)</td>
<td>1000A at 2kHz</td>
<td>48 caps, 24 in</td>
<td></td>
<td>x 2 in series</td>
<td>86.4 litres</td>
<td>2.1mΩ</td>
<td>1.1 x Un</td>
</tr>
<tr>
<td>Metallised Polypropylene</td>
<td>5.4mF</td>
<td>900V</td>
<td>456A (x 3) at 50°C</td>
<td>3 units in parallel</td>
<td>28.5 litres</td>
<td>0.1mΩ</td>
<td>2 x Un</td>
<td>3 x Smaller</td>
<td></td>
</tr>
</tbody>
</table>
Small size | Low cost

DC Bias reduces capacitance

Can generate audible noise in some applications

Lowest ESR (1-10mohm)

X5R or X7R best temperature coefficient

Ceramic
Fig. 1. A multilayer ceramic capacitor exhibits cracking.

- Pad/Board Surface
- Ceramic Chip
- Termination
- Crack
- Solder Fillet
Fig. 3. The addition of a conductive polymer termination layer improves the mechanical flexibility of a ceramic capacitor.
Fig. 4. EIAJ RC3402 specifies the above setup (a) to measure a capacitor's ability to withstand flexing. If deflection produces a capacitance shift, the capacitor fails. A 1-mm deflection is used as an acceptance level for no failures (b).
The ESR of ceramic chip capacitor is approximately 1/100 of its cap.