i.MX6 Capacitor Placement

Issues & Recommendations

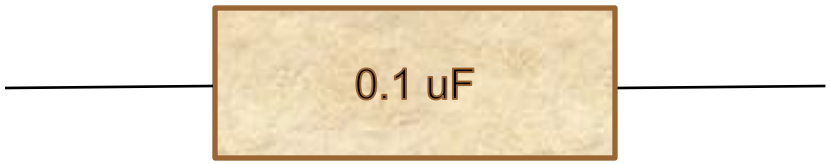
MPU Apps

Jun 2014- Rev1

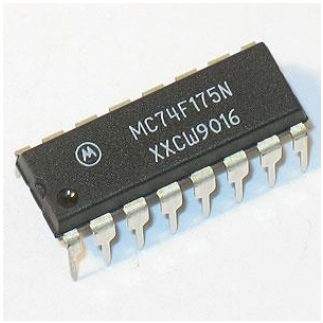
i.MX6 Bulk Capacitor Placement

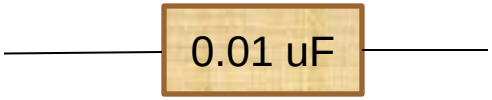
- For intensive operations, the i.MX6 IC may require a lot of power and may undergo large swings of instantaneous current requirements.
- Therefore, the power supply to the IC must be designed to handle relatively large surges of current with high di/dt
- Adequate power delivery from the power source to the processor load needs to be guaranteed. This is still critical if the internal regulators (LDO's) are bypassed.
- Correct placement and values of the decoupling and bulk capacitors is hence essential to ensure correct power delivery and operation of the IC.

Capacitor History



Higher Inductance
TTL, old CMOS





Lower Inductance
Schottky TTL, FAST

Then

Now

Same physical size
Similar inductance

Capacitor Sizing

Decouple

- Avoid → 0.01 uF and 0.1 uF
- Adopt → 0.22 uF, shared with 2-3 power balls each

  > 100 power contacts; can't place 0.01 or 0.1 uF cap per each
- OK → 0402
- Best→ 0201

Bulk

- Avoid wrong electrical size on LDO outputs
  - 22uF is the MAX on the _CAP outputs
  - If the nominal capacitance value is larger than recommended, power-up ramp time is excessive and operation cannot be guaranteed. Larger capacitors mean more inrush current. Select small capacitors with low ESR (Equivalent Series Resistance).
- Don't use bulk capacitors on VDD_SNVS_CAP
- Follow the IMX6DQ6SDLHDG (i.MX6 Hardware Development Guide) Rev 1 Table 2-6

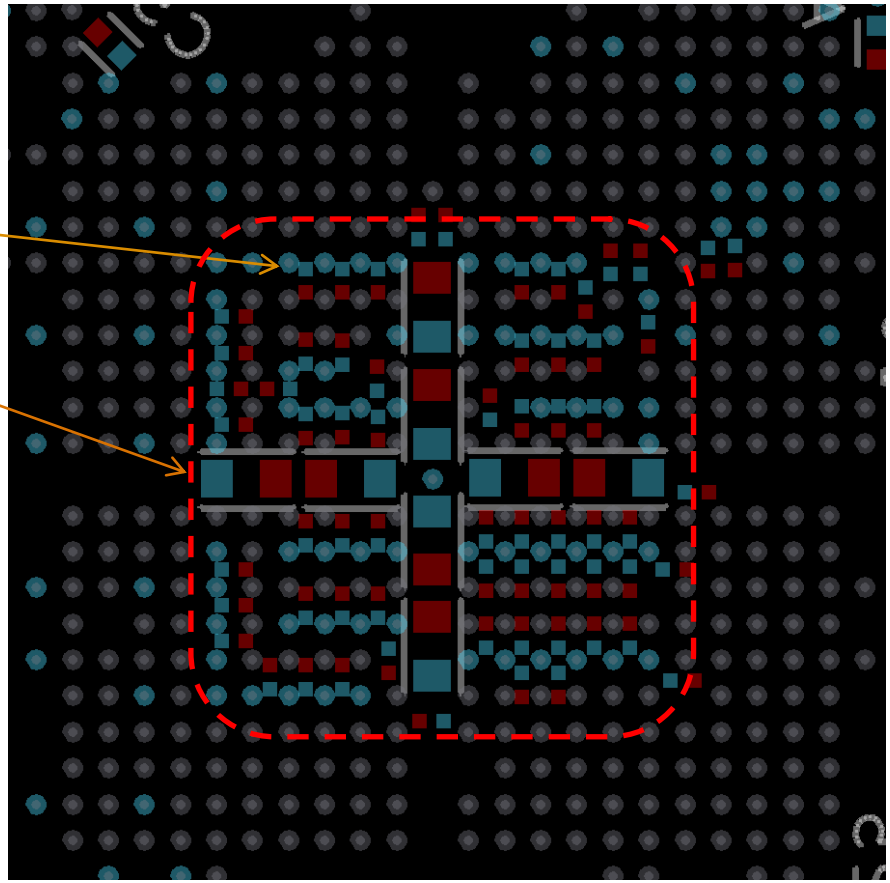
Decouple & Bulk Caps Placement

0201-0603 Under-the-BGA Attack

0.22 uF

10/22 uF

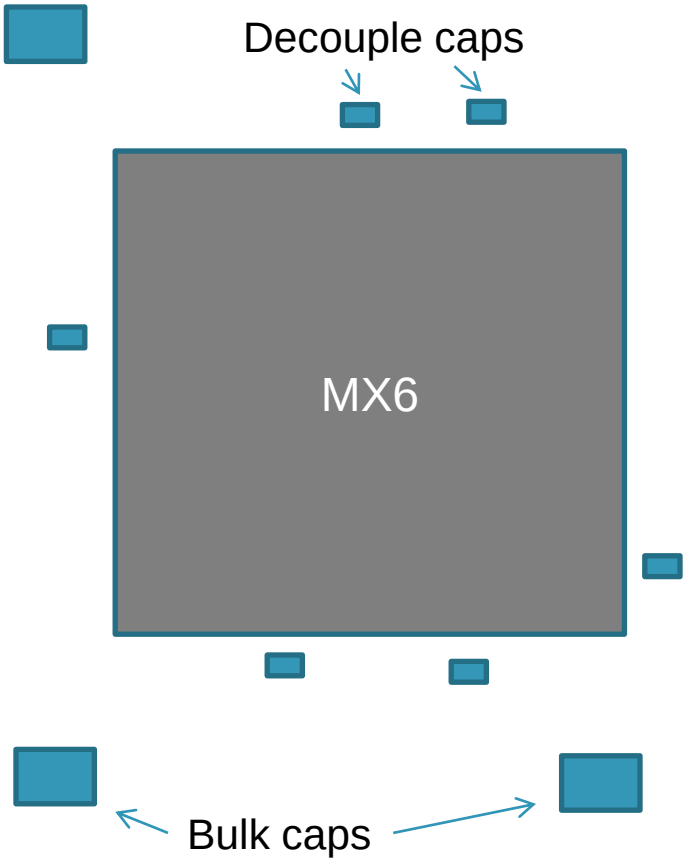
IMX6DQ6SDLHDG
Table 2-6



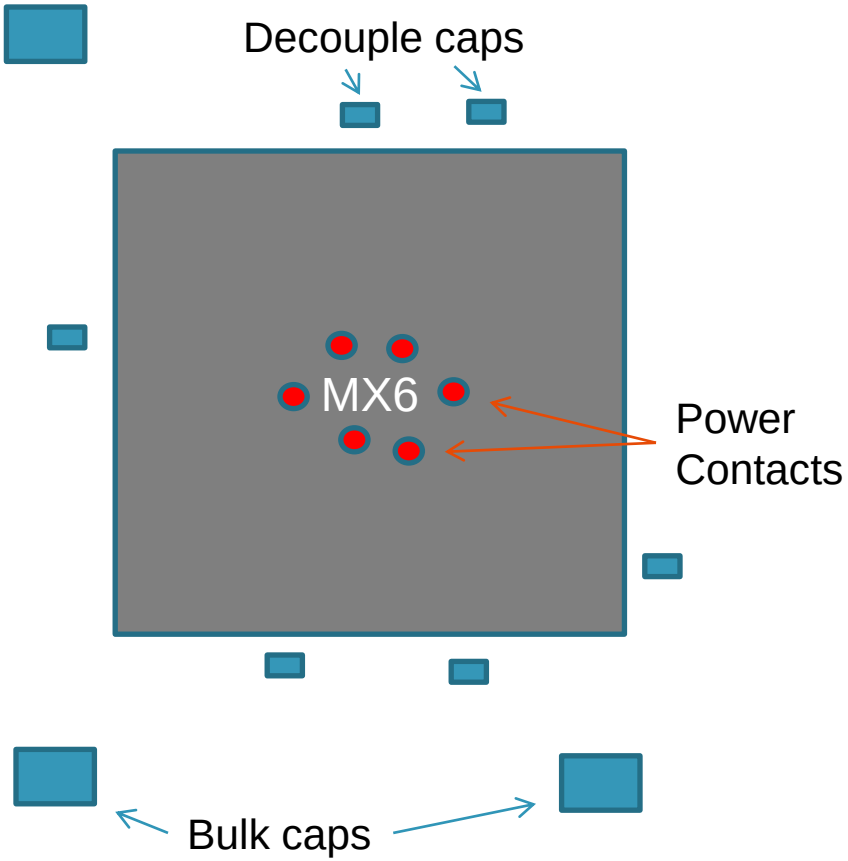
IMX6DQ6SDLHDG
Chap 3

Red = Pwr
Aqua = GND

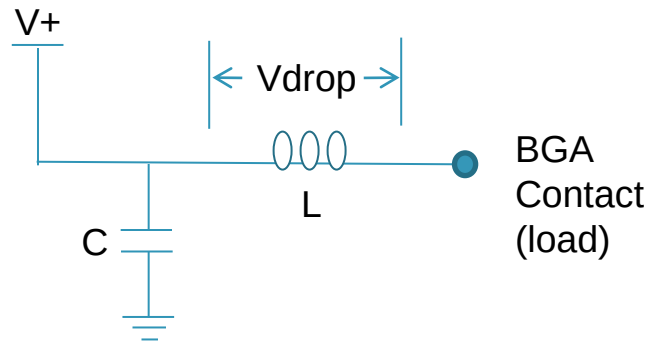
How to make i.MX6 fail



How to make i.MX6 fail

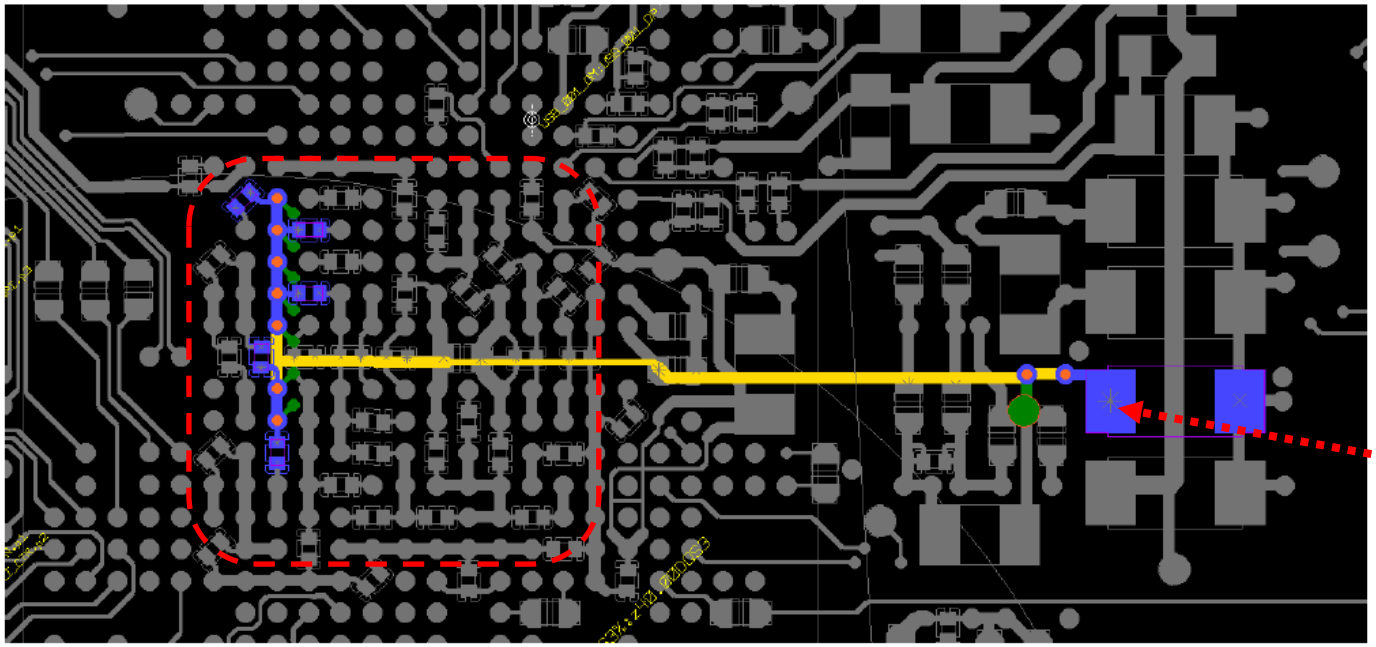


Why it fails



Vdrop = L (di/dt)

Example – Incorrect Capacitor Placement



Bulk capacitor is placed too far outside the IC perimeter - A trace length of less than 50 mil is recommended

- Increasing the bulk CAP value alone or move a little closer to the IC will NOT help much if power traces are treated as regular signal traces as shown above
- Recommend to use 1-oz copper planes / copper islands for the power rails and GND,
- Ensure appropriate number of power vias for the required current draw.
- The staggering approach should be used to place the various sized CAPs, where as the larger sized bulk CAPs (>= 100 uF) are further out and the smaller (2.2 uF) are closer and then the high freq CAPs (0.22 uF) are closest to the power balls as possible.
- The use of embedded capacitance in the stack-up is highly recommended.

Automotive Capacitor Placement Challenges

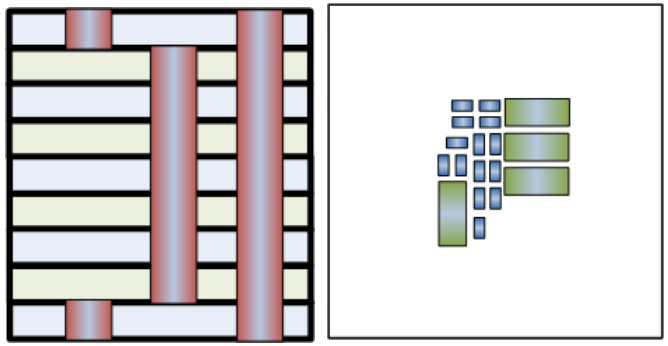
Challenge

- For Automotive cluster solutions, some customer designs are requiring larger bulk capacitors (4x size)

  22uF: 0603 → 1206

The i.MX6Q/D/DL/S package was not designed specifically for 1206 capacitors.

The bulk capacitors are still required to be placed under the processor.



Recommendation

- Use 10 layer HDI PCB technology (e.g. 10 layer PCB, 1-8-1)
  - Allows for the larger capacitors to be placed on bottom.
- VDD_ARM_IN, VDD_SOC_IN
  - Combine these two supplies into a single supply rail.
  - Place min 2x 0.22uF capacitors and 1x 22uF capacitor for this supply directly under chip in center.
- VDD_SOC_CAP, VDD_ARM_CAP, VDD_PU_CAP:
  - Place min 3x 0.22uF capacitors and 1x 22uF capacitor for each of these supplies directly under chip in center.

Notes

- Reference Design with 1206 caps will NOT be created because every Auto customer follows a different set of PCB routing rules.
- The i.MX6 SoloX derivative is being designed specifically for large bulk capacitor placement.

Automotive Capacitors Placement Issues

Potential issues caused by placing caps outside of chip perimeter:

- Display and Graphics issues.
- Random Memory bit errors.
- System hang during high processing events.

Issue Confirmation:

- Check the layout: Are the bulk caps placed outside of perimeter?
  - **If Yes, then try the following experiments to determine if it is a hardware PCB issue.**
    - Hand solder 22uF capacitors directly under center of chip. Solder on top of the 0402 chips.
    - Have software Increase voltages of ARM_CAP, SOC_CAP, PU_CAP.

Automotive Capacitors Placement Recommendations

Design Limitations:

- Minimize board cost.
- Caps may not fit under chip with custom layout rules.

Solutions:

- Check the layout: How far away are the bulk caps?
  - **Get the caps as close to the chip as possible.** (Within 1mm of chip perimeter)
  - Capacitor placement priority is _CAP closest, followed by _IN.
- Check the layout: How good is the power path between caps and chip center?
  - **Make sure they are using multiple vias near the bulk cap.**
  - **Make sure they have very wide traces to the center of the chip without any necks.**
- Increase the voltage of the "_CAP" power supplies:
  - **Stay within operating range listed in datasheet**
- Increase the capacitance of the "_IN" power supplies:
  - **Increase the capacitance per "_IN" near the chip.**
- Using a 22uF cap for the _IN supply assumes that your power supply is very close to the i.MX6 chip and that the power supply can compensate quickly to load changes.
- Add 0603 size caps (4.7uF) under chip in addition to the 22uF caps. (1 per supply)
- 22uF, 0603 caps which are AEC-Q200 rated are now available and can be used in customer designs

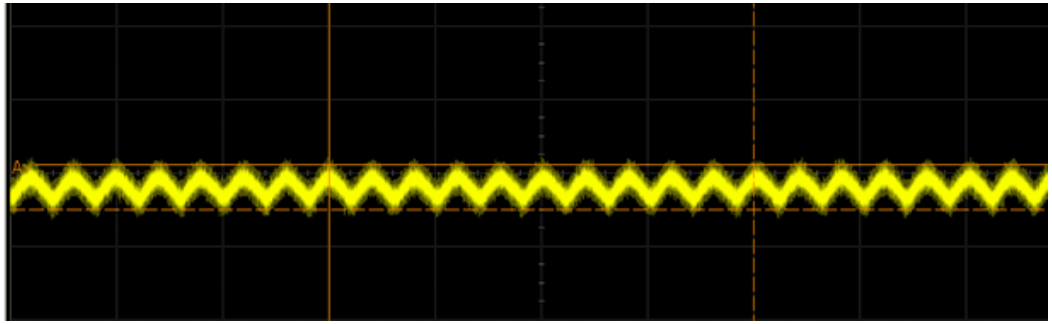
Capacitors Placement Recommendations

Solutions:

- Size the _IN capacitor such that the LDO is not starved when MX6 current demand suddenly increases.
- Consideration should be given to series inductance between the power source and MX6 load point.
- Capacitor placement priority is _CAP closest to the MX6 power ball, followed by _IN.

LDO Capacitor Requirements

- Correct sizing and placement of caps on the Regulator supply outputs are required to ensure stable regulator operation as well as providing the dynamic current demands
- If the value of the bulk capacitor on the regulator output is too low the regulator may become unstable leading to a saw tooth waveform on the output (shown below)



- In addition it may not have enough charge capacity to source the demands of the internal high frequency switching required by the application

References

- **MX6DQ6SDLHDG, Hardware Development Guide for i.MX 6Quad, 6Dual, 6DualLite, 6Solo Families of Applications Processors**
- http://cache.freescale.com/files/32bit/doc/user_guide/IMX6DQ6SDLHDG.pdf?fpsp=1
- **SABRE for Automotive Infotainment Based on the i.MX 6 Series**
- http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=RDIMX6SABREAUTO
- **SABRE AI : Design files, including hardware schematics, layout files and BOM.**
- https://www.freescale.com/webapp/Download?colCode=i.MX6_SABRE_AI_DESIGNFILES&appType=license&location=null&fpsp=1&WT_TYPE=Schematics&WT_VENDOR=FREESCALE&WT_FILE_FORMAT=zip&WT_ASSET=Downloads&sr=71&Parent_nodeId=13376371545356958310 62&Parent_pageType=product&Parent_nodeId=13376371545356958310 62&Parent_pageType=product

www.Freescale.com