EMI solution for DC/DC converter (for automotive, 12V step-down type)
Contents

EMI solution for DC/DC converter
(for automotive, 12V step-down type)

1. Initial noise
2. Noise propagation mechanism
3. EMI solution
4. Summary
1. Initial noise
1. Initial noise : Evaluation sample

Evaluation sample

- Step-down DC/DC converter from 12V to 5V
  - $I_{in} = 0.3A$, $I_{out} = 0.7A$
- Switching frequency = 400kHz
1. Initial noise

: Conducted emission (0.15 - 108MHz)

*Measurement system*

**Result** ex. Power line / average

Noise interval is 400kHz, same as switching frequency of DC/DC converter.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Model</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISN</td>
<td>NNBM8125</td>
<td>SCHWARZBECK</td>
</tr>
<tr>
<td>12V Battery</td>
<td>GHC-40B19R</td>
<td>GS Yuasa</td>
</tr>
<tr>
<td>Spectrum Analyzer</td>
<td>ESU26</td>
<td>ROHDE&amp;SCHWARZ</td>
</tr>
<tr>
<td>Amplifier (Use only 30 – 108MHz)</td>
<td>N310</td>
<td>Sonoma</td>
</tr>
</tbody>
</table>
1. Initial noise
: Radiated emission (0.15 - 30MHz)

Measurement system

Result ex. Vertical / average

Noise interval is 400kHz, same as switching frequency of DC/DC converter.

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<thead>
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<th>Instrument</th>
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<tr>
<td>LISN</td>
<td>NNB M8125</td>
<td>SCHWARZBECK</td>
</tr>
<tr>
<td>Monopole Antenna</td>
<td>3301B</td>
<td>ETS-LINDGREN</td>
</tr>
<tr>
<td>12V Battery</td>
<td>GHC-40B19R</td>
<td>GS Yuasa</td>
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<td>ESU26</td>
<td>ROHDE&amp;SCHWARZ</td>
</tr>
</tbody>
</table>
1. Initial noise: Radiated emission (30 - 300MHz)

**Measurement system**

- Anechoic Chamber
- Biconical Antenna
- GND Plane
- EUT
- Styrene Foam
- 12V Battery
- LISN
- LISN

**Result**

- Noise interval is 400kHz, same as switching frequency of DC/DC converter.

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<tr>
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2. Noise propagation mechanism
2. Noise propagation mechanism: Conducted emission (0.15 - 108MHz)

0.15 - 108MHz ex. Power line / average

Ferrite core attached to power cable

Ferrite core attached to power & GND cable

- Noise was reduced at all frequencies.

- No change.

⇒ Noise appearing as conducted emissions, differential mode noise is dominant.
2. Noise propagation mechanism
   : Radiated emission (0.15 - 30MHz)

0.15 - 30MHz ex. Vertical / average

- Ferrite core attached to power cable
- Ferrite core attached to power & GND cable
- Shield attached to PCB.

Noise appearing as radiation emissions,
  - radiation from PCB is dominant at under 20MHz,
  - radiation of common mode noise from harness is dominant at over 20MHz.

=> No change.

=> Noise was reduced at over 20MHz.

=> Noise was reduced at under 20MHz.
2. Noise propagation mechanism
   : Radiated emission (30 - 300MHz)

30 - 300MHz ex. Vertical / average

Ferrite core attached to power cable

![Diagram showing noise reduction with ferrite core attached to power cable]

- Noise was reduced at many frequencies.  

Ferrite core attached to power & GND cable

![Diagram showing noise reduction with ferrite core attached to power & GND cable]

- Noise was reduced at a few frequencies.

Noise appearing as radiation emissions,
- radiation of common mode noise from harness is dominant.
- but, at a few frequencies, radiation of differential mode noise from harness is dominant.
3. EMI solution
3. **EMI solution**

: **EMI solution policy**

Noise reduction according to the following policy.

- **EMI solution for conducted emission**
  
  -> Insert LPF near power connector.  --- solution for all frequencies.
  
  ex. LQH5BPZ4R7NT0 + GCM188R71E105KA49

- **EMI solution for radiated emission**
  
  -> Shield attached to PCB.  --- solution for under 20MHz
  
  -> Insert CMCC near power connector.  --- solution for over 20MHz
  
  ex. PLT5BPH5013R1SN

  -> Insert LPF near power connector.  --- solution for over 20MHz

* in some case, same as EMI solution for conducted emission.
3. EMI solution

: Characteristics of EMI filter

LPF: 10uF + 4.7uH + 1uF

![Graph showing S21 dB vs frequency for LPF and CMCC](image)

CMCC: PLT5BPH5013R1SN

![Graph showing impedance vs frequency for CMCC](image)

IL = 80dB @ 400kHz
IL = 110dB @ 100MHz
* IL > 90dB @ AM Band
* IL > 100dB @ FM Band

Z_C = 750ohm @ 20MHz
Z_C = 300ohm @ 300MHz
* Z_C > 1000ohm @ FM Band

LQH5BPZ4R7NT0

Rated current: 3A
Size: 5.0-5.0-2.0mm
AEC-Q200: O.K.

PLT5BPH5013R1SN

Rated current: 3.1A (line up is max 5.6A)
Size: 5.0-5.0-5.0mm
AEC-Q200: O.K.

⚠️ You have to select item which have high noise reduction performance at frequency that you want to reduce noise.
3. EMI solution

: Conducted emission (0.15 - 108MHz)

EMI solution

By the EMI solution, it is possible to satisfy CISPR25 class5.
3. EMI solution
: Conducted emission (0.15 - 108MHz)

By the EMI solution, it is possible to satisfy CISPR25 class5 in all measurement items.
3. EMI solution

Radiated emission (0.15 - 30MHz)

EMI solution

Only CMCC

Only shield

By the EMI solution, it is possible to satisfy CISPR25 class5.
3. EMI solution
: Radiated emission (0.15 - 30MHz)

By the EMI solution, it is possible to satisfy CISPR25 class5 in all measurement items.
3. EMI solution
: Radiated emission (30 - 300MHz)

EMI solution

![EMI Solution Diagram]

Result ex. Vertical / average

By the EMI solution, it is possible to satisfy CISPR25 class5.
3. EMI solution
: Radiated emission (30 - 300MHz)

Ref. All measurement items

By the EMI solution, it is possible to satisfy CISPR25 class5 in all measurement items.
4. Summary
EMI solution for DC/DC converter

- Conducted emission
  - (1) Insert LPF near power connector. --- solution for all frequencies.
    ex. LQH5BPZ4R7NT0 + GCM188R71E105KA49
  - (2) Insert CMCC near power connector. --- solution for over 10MHz.
    ex. PLT5BPH5013R1SN

- Radiated emission
  - (3) Shield attached to PCB. --- solution for under 20MHz
  - (4) Insert CMCC near power connector. --- solution for over 20MHz
  - (5) Insert LPF near power connector. --- solution for over 20MHz

* In some case, (4) (5) are same as (1) (2).
(Appendix) Verification of EMI solution
(Appendix) Verification of EMI solution

: Evaluation sample

- Step-down DC/DC converter from 12V to 5V
  $I_{in} = 0.3A$, $I_{out} = 0.7A$
- Switching frequency = 2MHz

We verified about other sample which switching frequency and PCB pattern are different from previous sample.
(Appendix) Verification of EMI solution
: Conducted emission (0.15 - 108MHz)

EMI solution

\[ \begin{align*}
&12V \\
&\text{PLT5BP/501} \quad 4.7\mu H \\
&1uF \\
&225\mu F \\
&10\mu F \\
&6.7\text{ohm}
\end{align*} \]

Result

\[ \begin{align*}
\text{Noise level [dBuV/m]} \\
\text{Frequency [MHz]}
\end{align*} \]

By the EMI solution, it is possible to satisfy CISPR25 class 5.
(Appendix) Verification of EMI solution: Radiated emission (0.15 - 30MHz)

EMI solution

Result ex. Vertical / average

By the EMI solution, it is possible to satisfy CISPR25 class5.
(Appendix) Verification of EMI solution : Radiated emission (30 - 300MHz)

EMI solution

By the EMI solution, it is possible to satisfy CISPR25 class5.
(Appendix) Verification of EMI solution

EMI solution for DC/DC converter
- Conducted emission
  -> (1) Insert LPF near power connector. --- solution for all frequencies.
    - ex. LQH5BPZ4R7NT0 + GCM188R71E105KA49
  -> (2) Insert CMCC near power connector. --- solution for over 10MHz.
    - ex. PLT5BPH5013R1SN

- Radiated emission
  -> (3) Shield attached to PCB. --- solution for under 20MHz
  -> (4) Insert CMCC near power connector. --- solution for over 20MHz
  -> (5) Insert LPF near power connector. --- solution for over 20MHz
    * In some case, (4) (5) are same as (1) (2).

* For simplify, both 400kHz and 2MHz DC/DCC converters are used same LPF.
  But actually, it is effective that L and C are changed depending on frequency which you want to reduce noise.