AltiumLive
The Next 60 Minutes...

AltiumLive 2017
  - Do you remember?

Common pitfalls 2018
  - Top 10 EMC issues

Help me – it’s automotive
  - some automotive trouble
  - EVs approaching

Live review/discussion
AltiumLive | Who am I

Thomas Wischnack (aka Dl3IT/AC4UX)

> Hardware development since 1993
> 9 years working for AST (automated guided vehicles)
  – Hardware for control systems, sensors, interface and communication (LF, RF)
  – Software (embedded, PC, FPGA)
> 16 years working for Porsche Engineering
  – Hardware/software development
  – System design
  – Troubleshooting
  – EMC consulting

> Why PCB doctor?
  – I don’t know... Ask Altium...
Great event with endless good discussions

Many surprised people, about the topics presented

- High speed design
- Apply filters correctly
- Component selection
- Switching voltage regulators
- Layer stack

Any improvement during the last year?
Common Pitfalls 2018

Top 10

1. Switching voltage regulators
2. Ground flooding
3. High speed routing/impedance control
4. Layer stack
5. Filter placement/routing
6. Ground layout
7. Common mode chokes
8. Connector placement
9. Copy and paste
10. Case grounding

(The same procedure as every year... )
Common Pitfalls 2018

Case grounding

- Don’t connect your case with DC connection to ground
  - Avoid unpredictable ground loops
  - Unpredictable GND currents
  - Filters don’t act as filters anymore
- Make RF connection with \(R \parallel C\)
  - Good start value: 100K-1M and 10n-100n
  - Depends on relevant frequency range

Copy and paste

- „I don’t know, why this component is placed here. It’s not my design... I had to reuse it...“
- Unknow/not fully understood designs lead to trouble in almost 100%
- If you don’t understand the design – DON’T USE IT
- Designs might have worked before, but most likely in another context
- Designs aren’t good, just because they exist
Common Pitfalls 2018

Connector placement

- Bad places for connectors
  > On every edge of the PCB, all with GND and power connections, mixed signals
  > In the center of the PCB and on the edges

- OK places
  > One (!) connector in the center

- Great places
  > All connectors on ONE edge

- Unpredictable cross currents through your PCB
- Unpredictable behaviour of filters
- Significant effort for filtering on every connector
- ESD critical shoot through
Common Pitfalls 2018

> **Common mode chokes**
  - Are not bad by nature
  - Are useful for symmetrical signals
  - Are of limited use for unsymmetrical signals (but mostly used)
  - Save sometimes 3dB
    > But don’t fix the problem
  - Make EMC engineering almost impossible due to the blocking of the return path
  - Are a good indicator of the „layout quality“

> **Ground layout**
  - Remember 2017?
    > How many grounds are necessary?
    > AGND, PGND, SGND, DGND, FGND...
  - Where is the return path for your signals?
  - Voltage is the difference between two potentials
    > Reference potential?
Common Pitfalls 2018

> Filter placement/routing
  - Voltage is the difference of two potentials
  - Many filter components act on voltage difference
    > If the current does not pass by, the filter does not see it and can’t do anything
  - Placement of filters is critical
    > Filters „in the middle of nowhere“ are useless (also valid for some spare 100nF capacitors…)

> Layer stack
  - No impedance matched routing without an appropriate layer stack
    > Even, if project management insists
    > Even, if the PCB is more expensive
  - Ask your PCB manufacturer for assistance in defining your layer stack
  - Not every possible setup is useful
    > 6 layers are good
    > 8 layers not quite useful
    > 10 layers are good
High speed routing

- High speed signals without impedance match cause EMC trouble
  - Always
  - Even, if... (you know...)
- High speed does not only depend on the base frequency
  - Harmonics are much more critical
  - Low speed signals can have lots of harmonics, depending on the driver stage
- Series resistance is cheap and make impedance matching possible
- Common ground planes as reference planes are a MUST
- Only ONE (in words: 1) common ground for high speed systems

„Physics always wins“
Ground flooding (my favorite...)

- Most often seen in combination with "common mode chokes in power lines"
- Unnecessary with correct layer setup
  - Do you really want to shield GND layers with GND flooding on top/bottom?
- Unpredictable ground currents
- Unpredictable reference for high speed signals
- Unpredictable reference for voltage sensitive applications (measurement)
- Unpredictable filter behaviour
- Gives the famous foggy hills in the EMC spectrum
  - Fog cannot be cleaned without removing the flooding and making a proper layout
- Capacitive load on every line
  - Output driver tries to load this capacitor
  - Unnecessare peak loads for the power supplies
Common Pitfalls 2018

> Switching voltage regulators
  - TOP 1 root cause for EMC issues
  - Can produce trouble up to 1GHz
  - Newer parts are most often the better choice
    > The manufacturer did their homework
  - High frequency devices tend to be less painfull
    > Components are smaller
    > Placement can be smaller
    > Smaller loops
  - Main design failures:
    > Switch node far too big (in terms of space, loop size)
    > GND layout
    > Capacitor selection (low ESR)
    > No shielded inductors
    > Filter application wrong
Help me – It’s Automotive

> Automotive is not bad – it’s (a bit) different
  - Automotive companies have their own design rules
  - Designs are tested intensively
    > Even the smallest sidenote in the requirements docs will be tested
  - Not every part/component is available/allowed
  - Automotive designs are negotiated very hard
    > Unexpected filter components can be a big cost issue no one will be paying for
  - Car power systems are never „clean“
  - EMC limits are very low
    > 0dBµV, or even less
  - The distance to antennas is very short; sometimes a few centimeters
    > The least little radiation is observed immediately
Help me – It’s Automotive

> How to avoid bad experience
  – Don’t make your first automotive design on your own
    > Seek for experienced help
  – Every requirement that is written in any requirement spec is important
    > Even, if you don’t think it’s necessary
    > Even, if it’s not obvious at the beginning of a project
  – Do intensive research on the design rules of the OEMs
    > E.g. VW 80000 and later versions
    > This is not a single document; this is a library
    > Read everything!
  – Automotive components
    > Long term supply necessary
    > Are sometimes hard to get
    > Are more expensive than industrial grade
      – (but not necessarily better)
Help me – It’s Automotive

> How to avoid bad experience

- Automotive industries is the mother of process oriented development
  > Be prepared for the overhead caused by project management, documentation, ...
EVs Approaching

> EVs are not new
  - First electrical Porsche was build in 1898
  - Fork lifters, service cars are pretty much standard

> The system setup in an EV is „new“
  - High voltages
    > Up to 800V, 400A, 320kW for charging and battery systems
    > Insulation and safety requirements
    > Standards are not ready and work is in progress
  - Power converters
    > High power converters in small packages
    > High peak currents
    > Increasing switching frequencies due to SicMOS and GAN devices
  - Batteries
    > Lithium batteries with high energy density
This means...

- Power systems in cars are much (!) noisier than before
- Expect significant voltage (and current) peaks
- Expect strong magnetic fields
- New levels for the power supplies will be very likely
- Almost everything is more or less undefined
  - It’s all new
  - OEMs learn how to make EVs
  - Customers learn how to use EVs, and OEMs will it their concepts
- Standards are being made
  - (legal) Changes for existing system are more than likely
And now...

> The fun part...

Welcome to

(Mr. „AltiumLive 2017, he was tough enough to present his design for a live review“)

Rainer Beerhalter

and his design for a new live review