The Design Process – EMC Considerations for Successful Development and Delivery

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- Delivery of the final product along with compliant EMC performance can be challenging.
- We’ll examine several points associated with the development process that can lead to successful delivery – or to disaster.
- Presented will be cause and effect examples of these points and how disaster can be prevented.
• Topics

  • Design Process overview

  • Where compliance fits
    • Concept through delivery

  • Examples of gotchas that could have been avoided
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- Target market
- Market requirements
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Concept
- Target market
- Market requirements

Development
- Design
  - Hardware
  - Software
  - Documentation (manuals etc.)

Time to Market
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Concept
- Target market
- Market requirements

Development
- Design
  - Hardware
  - Software
  - Documentation (manuals etc.)

Qualification
- Testing
  - Mitigation
  - Approvals
  - Documentation

Time to Market
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- Concept
  - Target market
  - Market requirements
  - Design considerations
  - Can we do it?

- Development
  - Design
    - Hardware
    - Software
    - Documentation (manuals etc.)

- Qualification
  - Testing
    - Mitigation
    - Approvals
    - Documentation

- Sales
  - Revenue
    - $$$$$$
• Target Market
  • Industry Specific
    • Commercial
    • Automotive
    • ITE
    • Defense/Aerospace/Government
  • Domestic
    • US/Canada
  • International
    • European Union
    • Eastern Europe/Russia
    • Mexico/Latin America/Asia Pacific
• Market Requirements
  • Testing affected heavily – can affect the overall success
- **Compliance role during Conceptual Phase**
  - Understanding of the requirements for a given market or industry
    - Testing, documentation and marking/labeling
    - You want to sell it where?!
  - Based on these requirements, what are the potential ramifications to the overall design?
    - Hardened for immunity
      - Levels and type
  - **Costs**
    - Hardware implementation
    - Testing/Market entry
      - Payola, payola
• So we know what we want to make and where we’d like to sell it, what’s next?

• Development
  • Hardware
  • Software (Really?)
  • Documentation (may be language specific)

• Time to Market (ever present concern)
  • Varies with complexity of product and industry
  • Affects the bottom line
Executive Management

Mid-Level Management

Compliance
• **Development** - Where we should spend most of our time
  • Unfortunately this isn’t always the case (testing and mitigation)
  • **New Product considerations**
    • Physical/Mechanical
      • Shielded/unshielded enclosure
    • Circuit board design
      • Schematic review
      • Artwork review
    • Interconnecting cabling
      • Shielded/unshielded
      • Length and construction / UTP vs. Cat 5e
    • Installation Environment/Application
      • Residential/industrial
      • Indoors/outdoors
      • Hot/cold
• **Compliance Role during Development**
  • Based on device conceptual result
    • Provide guidance with regard to physical arrangement, construction, bonding and grounding
    • Review schematics and provide guidance early in the process
      • Component placement/selection
      • Compartmentalization
      • PCB stack up
    • Review PCB artwork revision (a) prior to prototype construction
      • Verify stack up and PDN design
      • Signal routing/termination
    • As appropriate address cabling and environmental issues
      • This may be industry driven
• **Example # 1**
  • AC/DC converter
    • 120V/60Hz in 48VDC out at 48W
    • Metal housing
    • 2 attaching cables
      • AC mains unshielded ~3ft* = 1/4λ @ 80MHz
      • DC output unshielded ~2ft** = 1/4λ @ 125MHz
    • Approximate size 1.5”H x 3”W x 4.5”L
    • SMPS in the 100-200kHz range

• **Class A Device**
• Not reviewed by Compliance Engineering – processes were not in place for ready review.
Example #1 = +26dB pk over the Class A Limit
Comfortable margin to Class A limit
• Example # 1

• Resolved with
  • 100+ plots later......
  • Addition of common mode filtering in the form of a wire-wound choke and ferrite beads
  • Layout change to PCB (x2-3)
  • Minor construction changes

• Functional design was great but development at this time did not include Compliance schematic/artwork review
• Later this device was successfully developed into a 100W and greater version w/o significant difficulty.
• Example # 2
  • Telecom service delivery platform
    • -48VDC
    • Sealed metal housing with shielded direct burial cables
    • Four PCB’s internally connected with header pins
    • *Original* approximate size is 6”L x 24”W x 30”H

• Class A Device
• The original device was compliant with the Class A limits
• Conversion of the device to a 2U high 19” rack mount configuration with unshielded cables and two PCB’s internally.
• Was the ‘same’ schematically
Previous unit performance
Example #3 = ~+18dB pk over the limit; Does it look the same?
Comfortable margin to Class A limit – looks more like the original
Example #2

Resolved with
  - Removal of 3-4 components
  - Relocation of Common mode filter closer to EUT input (board spin)

Design Engineering did not include Compliance in the schematic review as it was derived (copied) from a compliant product.

Compliance engineering was not included in the mechanical design or board layout phase of development.
• Example # 3
  • Custom high-end computer
    • Built from a combination of off-the-shelf devices (compliant)
    • Metal housing/dual display
    • 120V/60Hz – 240/50Hz auto-ranging supply
    • Attaching cables
      • PC peripherals
      • AC input cable
    • Approximate size 18”W x 24”L x 18”H

• Class A Device
• In-house compliance resource with no test capability
Example #1 = ~+6dB pk over the Class A Limit
Comfortable margin to the Class A limit
• Example #3

• Resolved with
  • Replacement of off-the-shelf power supply with a compliant power supply.
  • Treatment of shielded monitor cabling

• Power supply provided by Vendor A was thought to comply but in actuality did not.
• “Trust, but verify” – Ronald Reagan
• Example # 4
  • Custom computing/measuring device
    • Built from a combination of off-the-shelf devices and custom PCB’s
    • 120V/60Hz AC to 12VDC wall-wart converter
    • Off the shelf 12VDC to 5VDC converter internally
    • Plastic housing w/touch screen
    • Attaching cables
      • Custom measuring device in plastic housing
      • PC peripherals
      • AC/DC input cable
    • Approximate size 8’ cube
  • Class A Device
  • Start-up company with no in-house Compliance resource
Example #1 = +10dB pk over the Class A Limit
Marginally passes EU limit = ~3dB for USA
• Example # 4

• Resolved with
  • Re-positioning of internal components
  • Replaced off-the shelf DC-DC converter with PCB mounted regulator (this saved ~$80 in parts)
  • Used CE Mark approved lump-in-line for AC-DC conversion
  • Layout changes to custom PCB’s
  • Added a plethora of ferrite cores to internal peripheral cabling

• Compliance involvement didn’t begin until the unit was ‘ready’ for qualification prior to sale.

• No
• Problem solved; what now?
• Qualification
  • Mitigation
    • *If* one falls through the cracks during development, work with the lab
  • Testing
    • Relationship with accredited, competent laboratory facilities
• Approvals
  • Test plan should be developed to gain the widest reach of approvals in the most cost efficient way
• Documentation
  • Accurate Test reports
  • Declaration of Conformity/Labeling
  • Registration and Payola
Example # 5

Testing of product
- A2LA Accredited Test facility
- OATS with 3 and 10m capability
- Documented compliant NSA data
- Site registered and approved with the FCC

Class A Device
- Established company with in-house testing facilities
- Significant variation from expected result – variation from 3m distance to the 10m to great.
Laboratory Variations at 10m test distance - Vertical
• Example # 5

• Resolved with
  • Repair of discontinuity in ground plane at ~4m distance

• Anomaly had gone undetected at test facility – use of a noise source for site validation demonstrated the issue.

• Other issues detected at laboratories
  • Excessive moisture in Ground Plane structure
  • Cabling issues
• Compliance Role in Qualification/Approval
  • Mitigation
    • Emission/Immunity failure resolution
  • Testing
    • Coordination and monitoring of services provided
  • Approvals and Documentation
    • Accurate Test reports
      • Correct representation of the product and how it was tested
    • Declaration of Conformity/Labeling
      • CE MARK
    • Registration and Payola
      • NOM/VCCI and others
• **Summary**

  • Compliance processes aren’t a hurdle to jump over but an engineering resource for success

  • Involvement early in the process will shorten time to market and improve reliability – the earlier the better

  • Compliance costs overall will be reduced

  • Compliance people really aren’t so bad after all
What a day!