Design and Performance Evaluation of DUT Support Equipment for Automotive EMC Testing

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Agenda

- Introduction
- Characteristics of Support Equipment/Test Box
- Case Study – Phase 1
  - No Filtering
- Case Study – Phase 2
  - Traditional Filtering
- Case Study – Phase 3
  - Novel filtering techniques
- Test Box Design and Prove out Guidelines
- Conclusion

Introduction

- Automotive EMC Testing at module level
  - Radiated Emissions
  - Conducted Emissions
  - Radiated Immunity
  - Conducted Immunity
- EMC Test Plan
  - Define product
  - Test conditions
  - Define support equipment

EMC Test Plan Components

- Definition of EUT
- EMC requirements for EUT
- Stimuli and loads required to configure EUT in proper test modes
- Understanding of all power and I/O requirements
- Definition of support equipment
  - Interconnectivity to EUT and RF test setup
  - Monitoring of critical EUT functions
  - Description of how stimuli will be provided to EUT
  - Support equipment located inside/outside room

<u>All successful EMC tests begin and end with a proper EMC Test Plan</u>

Product EMC Requirements Trends

- Emissions – CISPR 25
  - Radiated: 10-30dBuV/m from 150KHz – 2.5GHz
  - Conducted: 10-40dBuV/m from 150KHz – 200MHz
- Immunity
  - Radiated: 100-200V/m from 1MHz to 6GHz
  - Conducted: 100-300mA up to 2GHz

Support Equipment Requirements

- Emissions – CISPR 25
  - At least 6dB below product emissions limit
- Immunity
  - Equal or better performance
- Extremely important to meet this criteria to maintain EMC Testing integrity
- Goal is to provide balance between EMC hardening and quality of stimulus provided

Test Boxes/Support Equipment

Off-the-shelf solution

- Easy to implement
- Built to conform to EMC standards (FCC/CE)
- Reduced development time
- Costs more

Custom built test box

- Accommodate unique applications
- Need to qualify EMC
- More development time
- Dedicated owner/team required

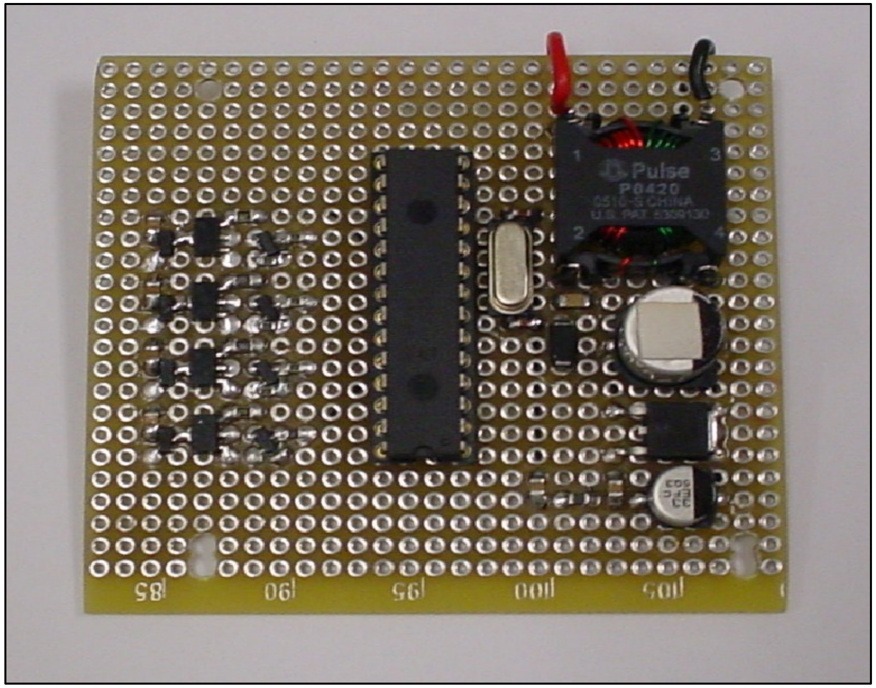
Often final solution is a combination of off-the-shelf and custom built solutions

Case Study - Introduction

Simple Test Box

Simple Test Box

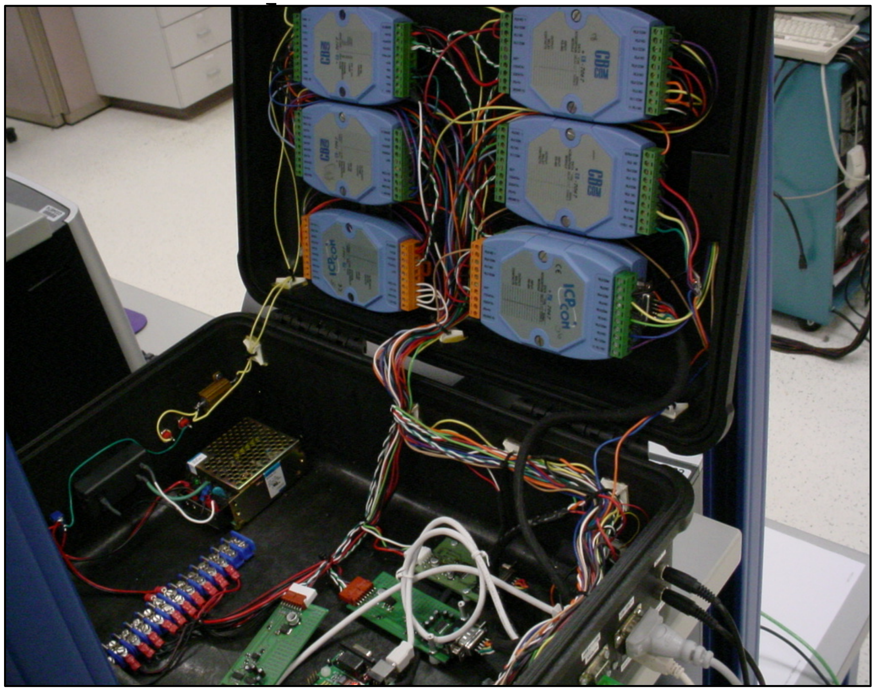
- Actuate LEDs on DUT



Complex test box

Complex Test Box

- Actuate a Telematics DUT



Case Study – Introduction (contd.)

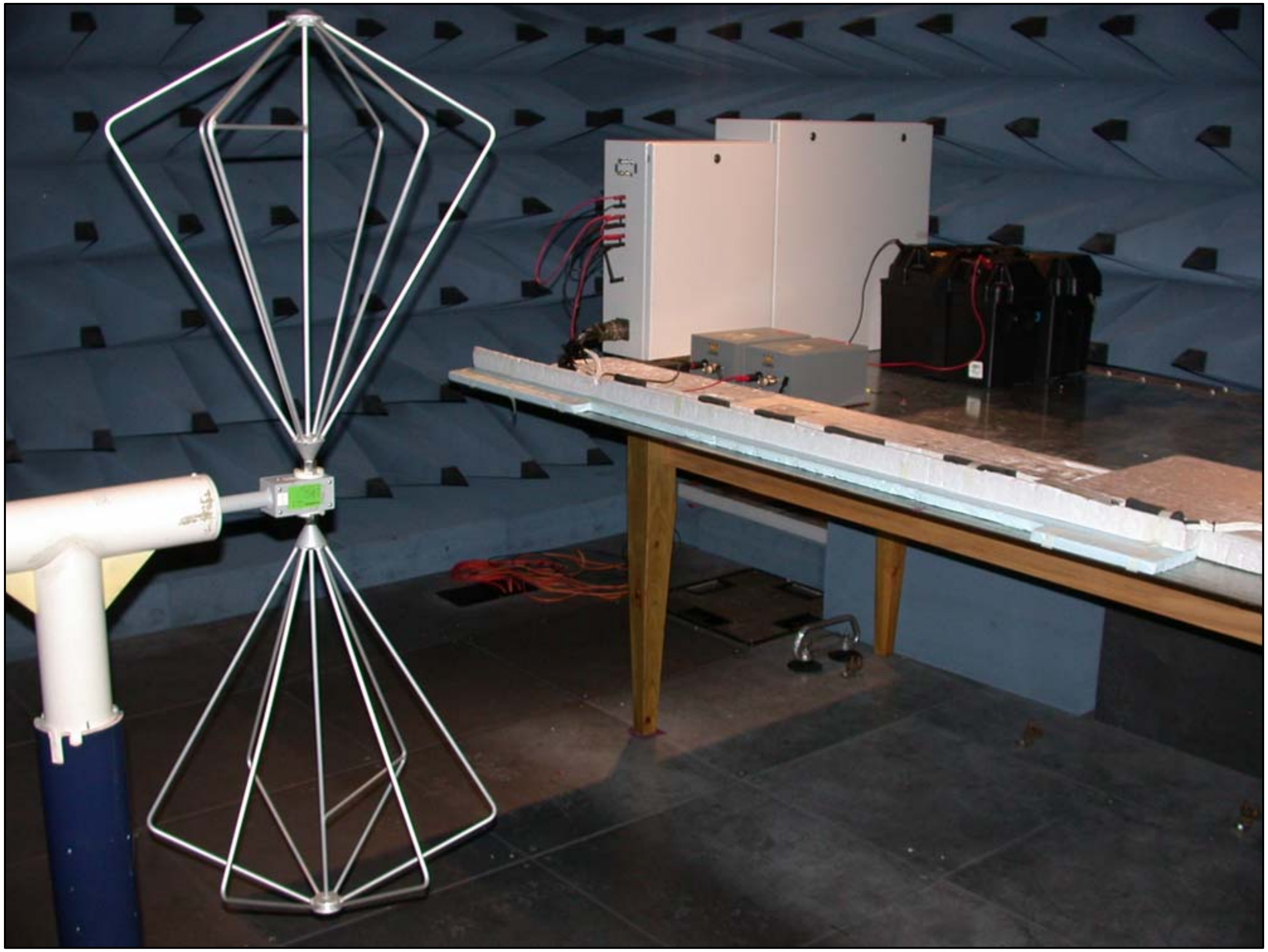
Simple Test Box (Contd.)

- Entirely custom-built
- CMOS Micro @ 20MHz
- Output driver
- Stand-alone unit – No external PC interface

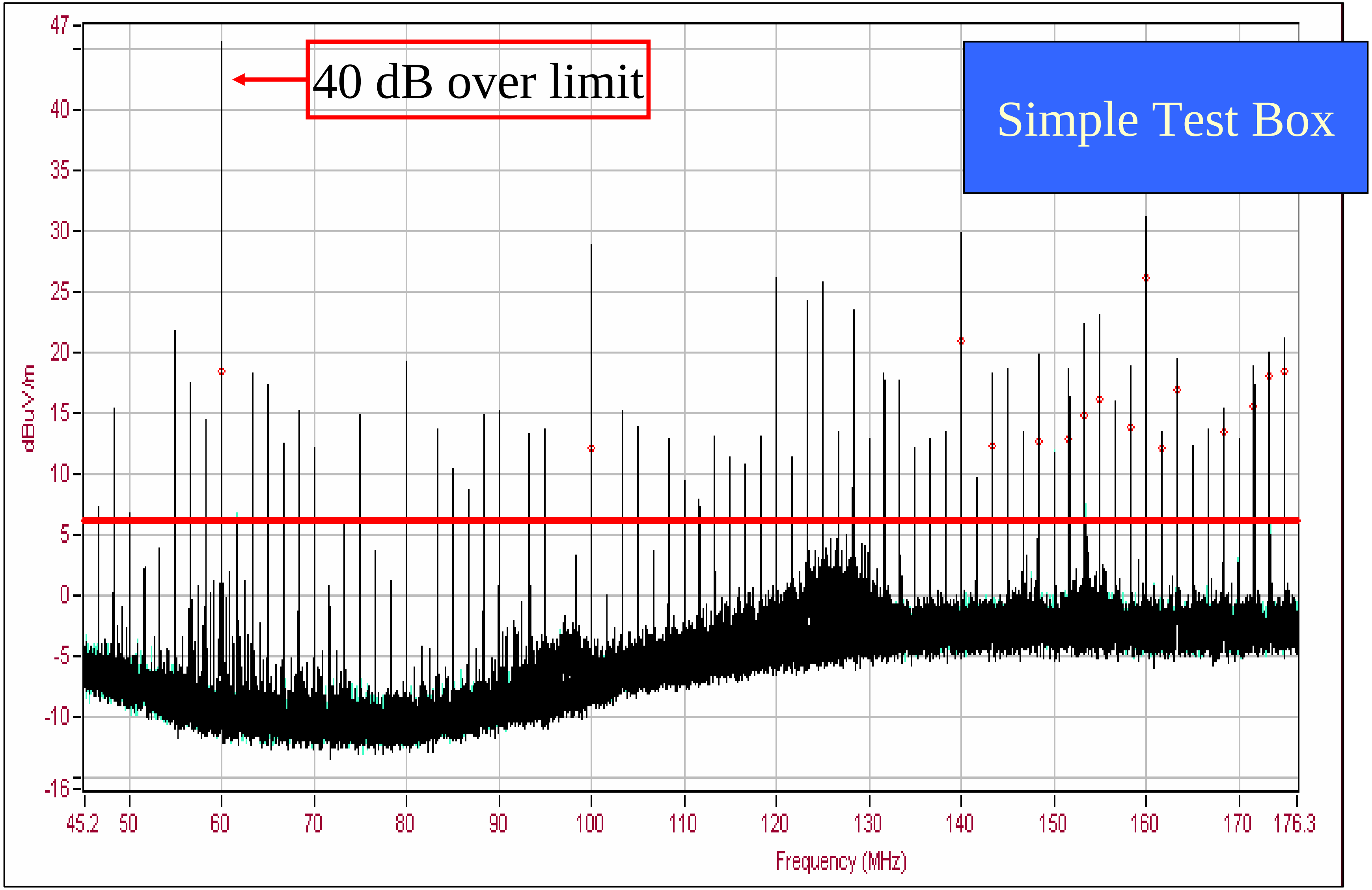
Complex test box (Contd.)

- Several off-the-shelf solutions integrated.
  - CB-COM
  - NEO-Vi
  - Fiber optic converters
  - USB to serial converters
  - Bluetooth dev. kit
- External PC-software interface through fiber

CISPR 25 Radiated Emissions setup

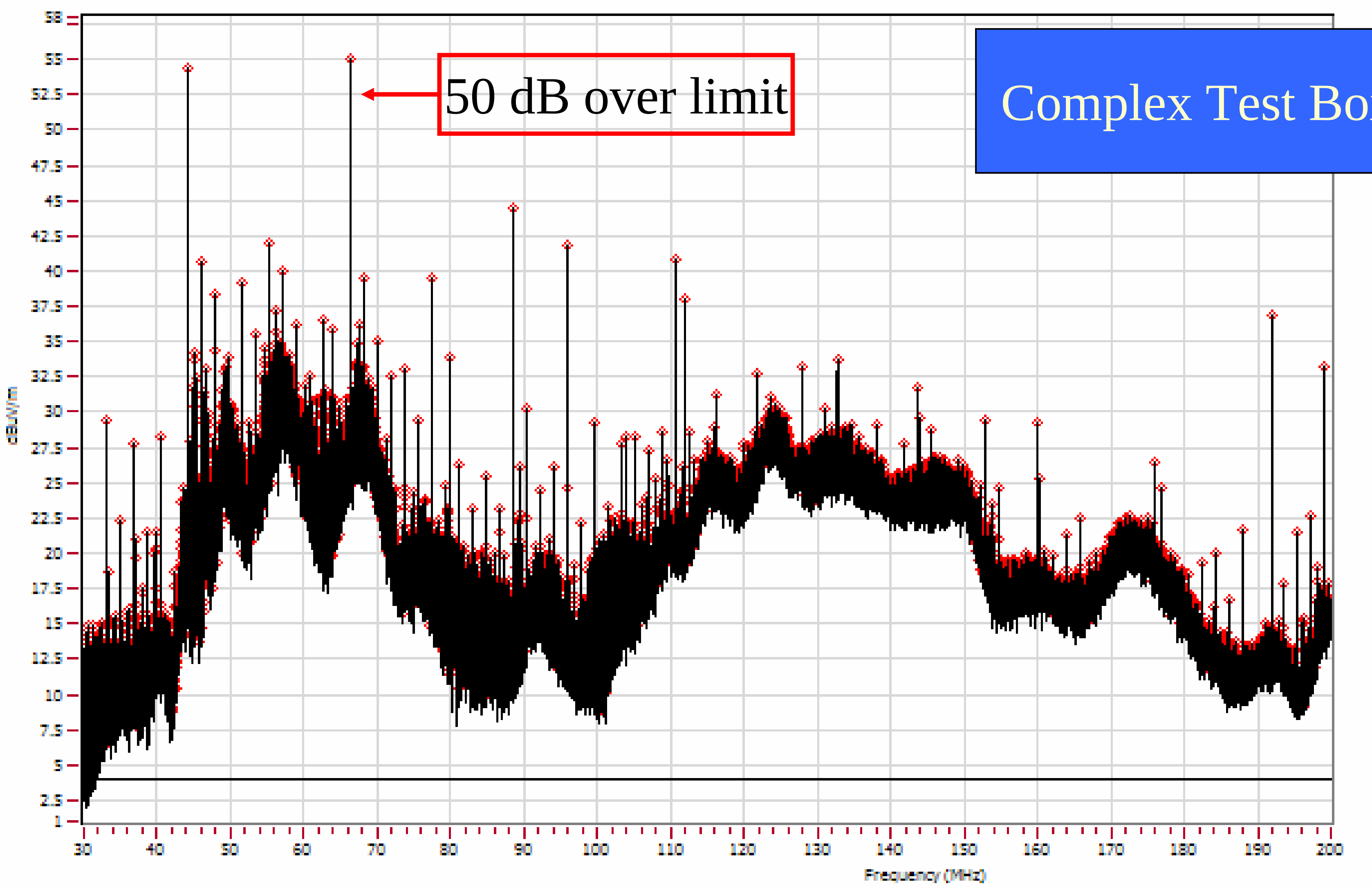


Radiated Emissions - Baseline



Radiated Emissions – Baseline (contd.)

Complex Test Box



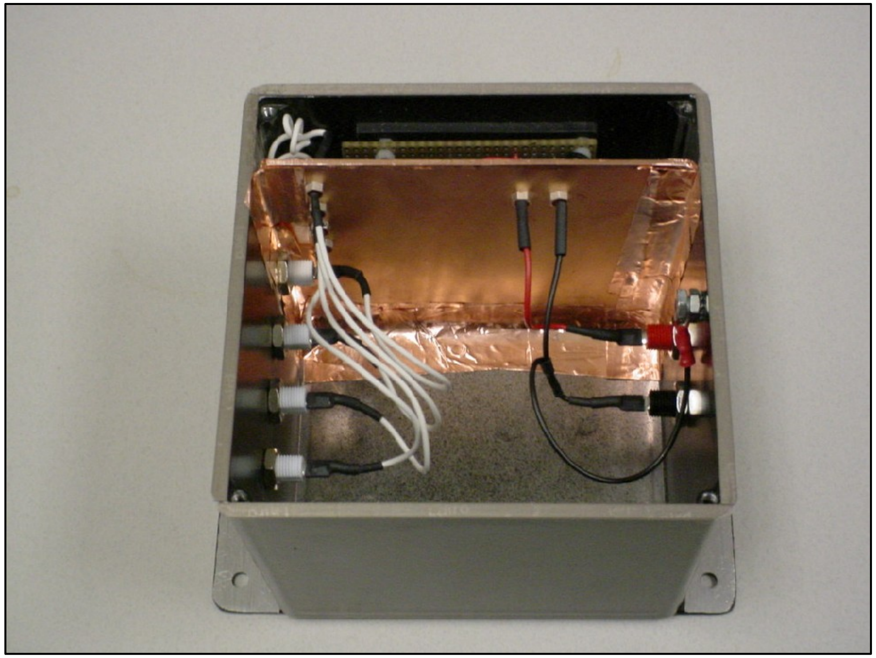
BCI Setup picture

Immunity Testing on Complex Test Box

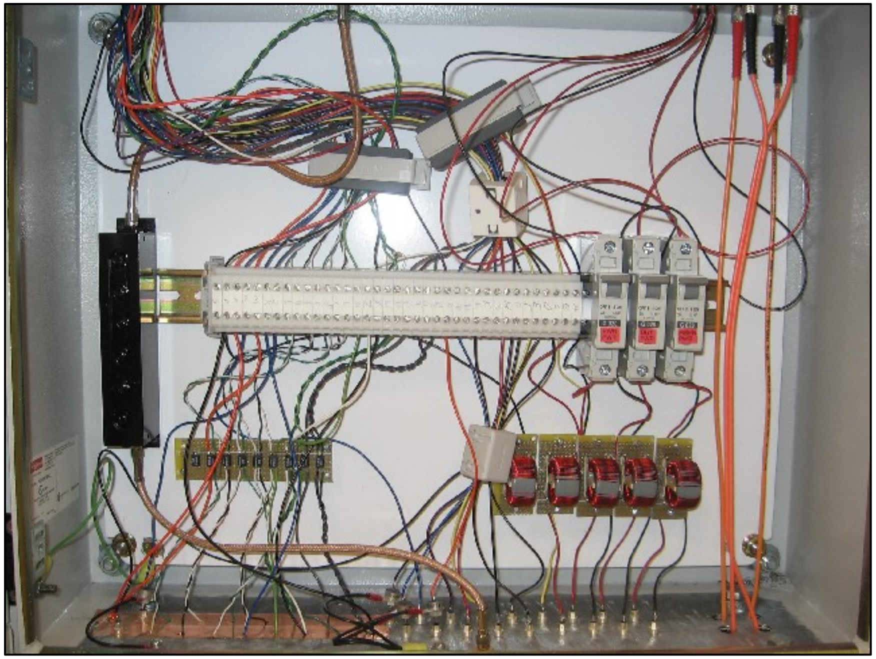
- Conducted Immunity – 130mA (Substitution method) from 1MHz to 2GHz
  - FAIL
- Conducted Immunity – 107mA (Closed loop method) from 1MHz to 200MHz
  - FAIL
- Radiated Immunity - 100V/m from 200MHz to 6GHz
  - FAIL

Traditional Filtering Approach

Simple Test Box

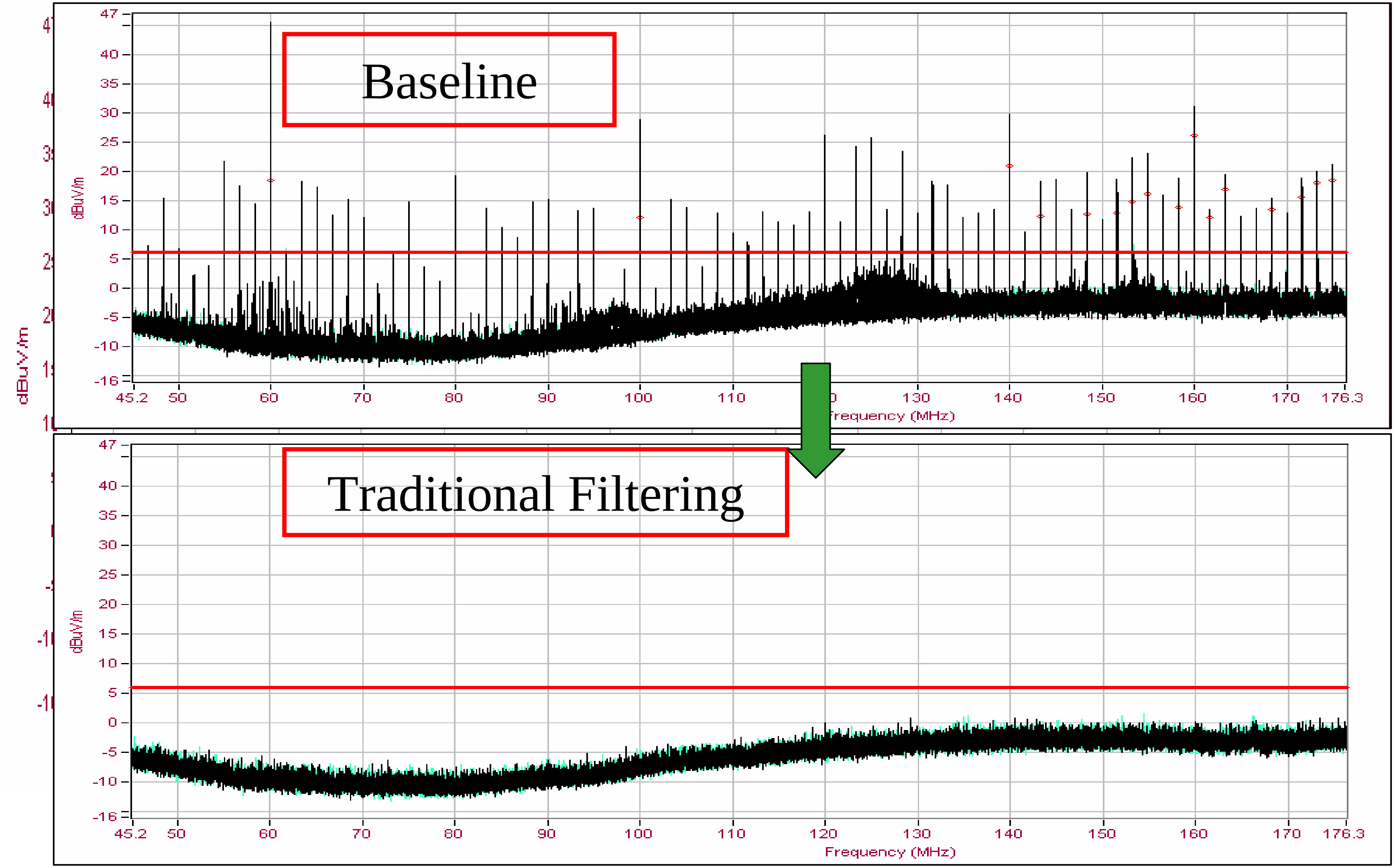


Complex Test Box



Radiated Emissions – Traditional Filtering

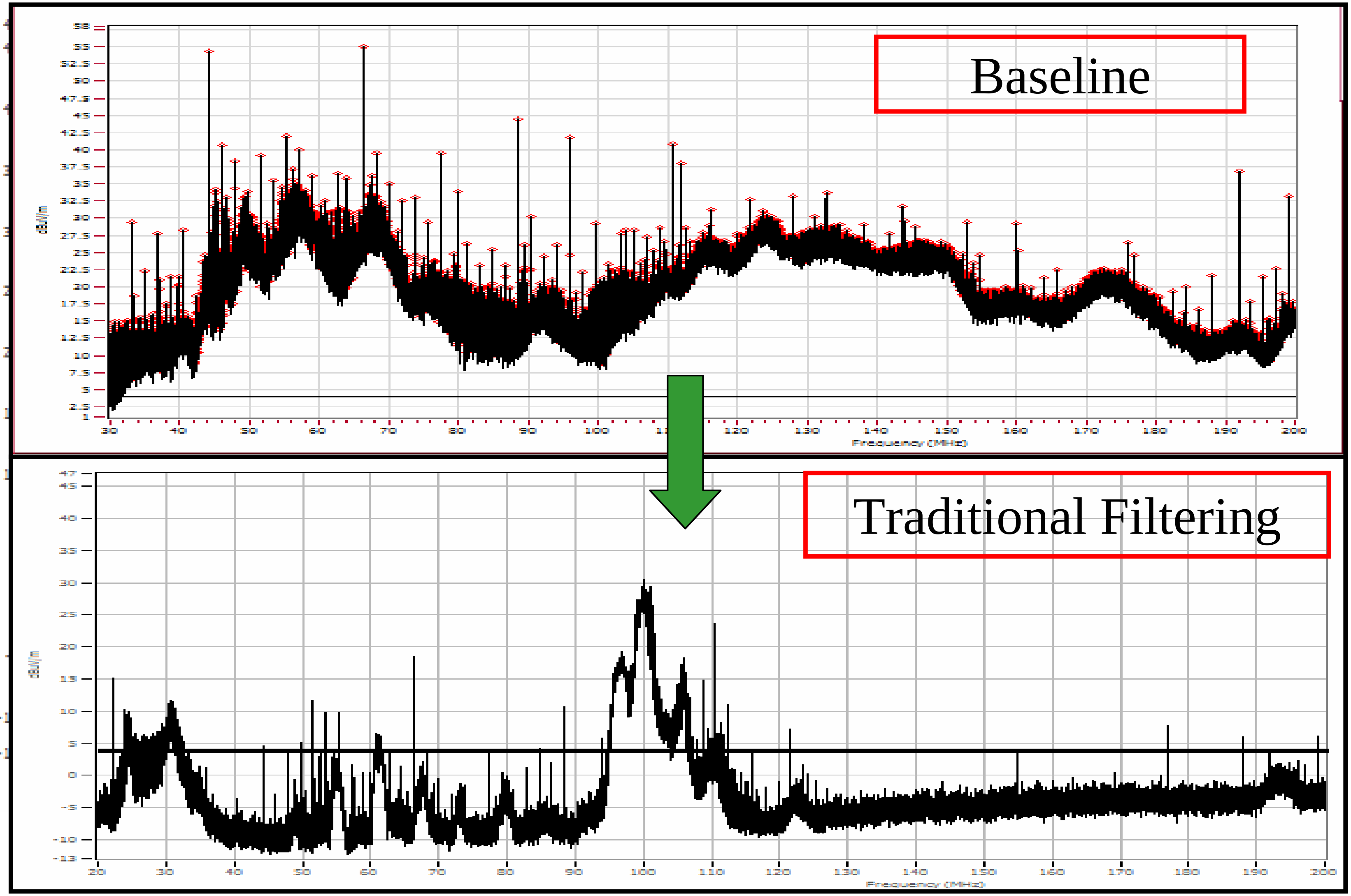
Simple Test Box



JOHNSON CONTROLS

Radiated Emissions – Traditional Filtering

Complex Test Box

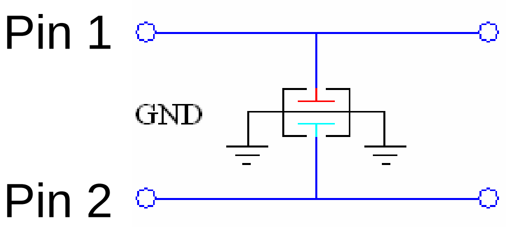


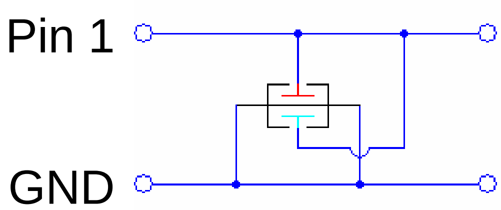
Other EMC Tests on Complex Test Box

- Radiated Immunity - 100V/m from 200MHz to 6GHz
  - **PASS**
- Conducted Immunity – 130mA (Substitution method) from 1MHz to 2GHz
  - **PASS**
- Conducted Immunity – 107mA (Closed loop method) from 1MHz to 200MHz
  - **PASS**

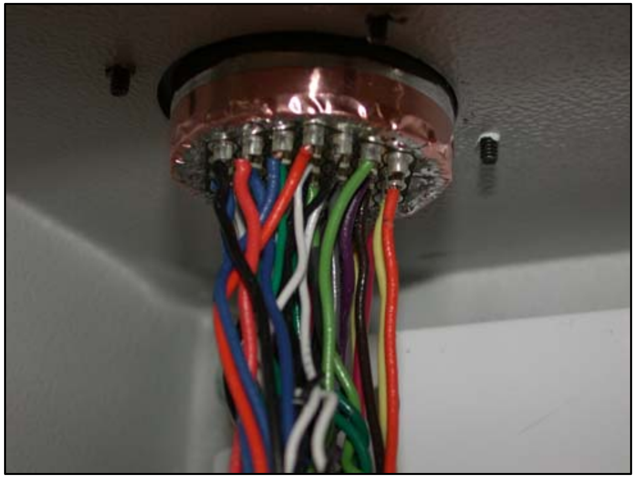
X2Y Filtering Approach

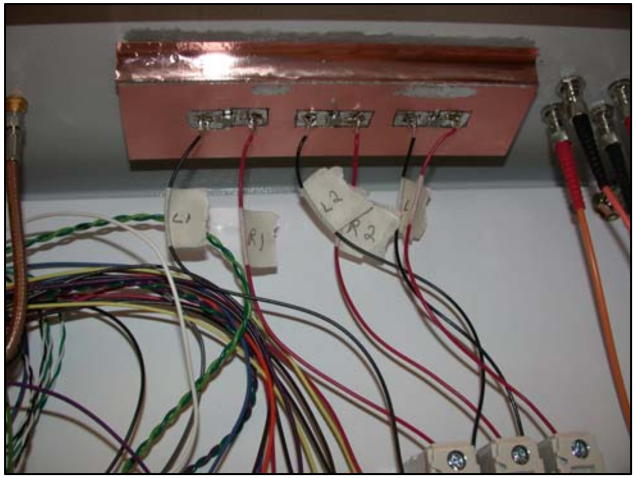
- X2Y located at exit point of connector of complex test box.
- Connector housing reference to complex test box for ground connection.
- X2Y attached in one of 2 configurations:
  - Circuit 1 configuration (preferred) – X2Y across 2 pins referenced to connector housing (GND)
  - Circuit 2 configuration – X2Y attached to 1 pin referenced to connector housing (GND)
- 5nF on all lines except on communication lines where 100pF was used.



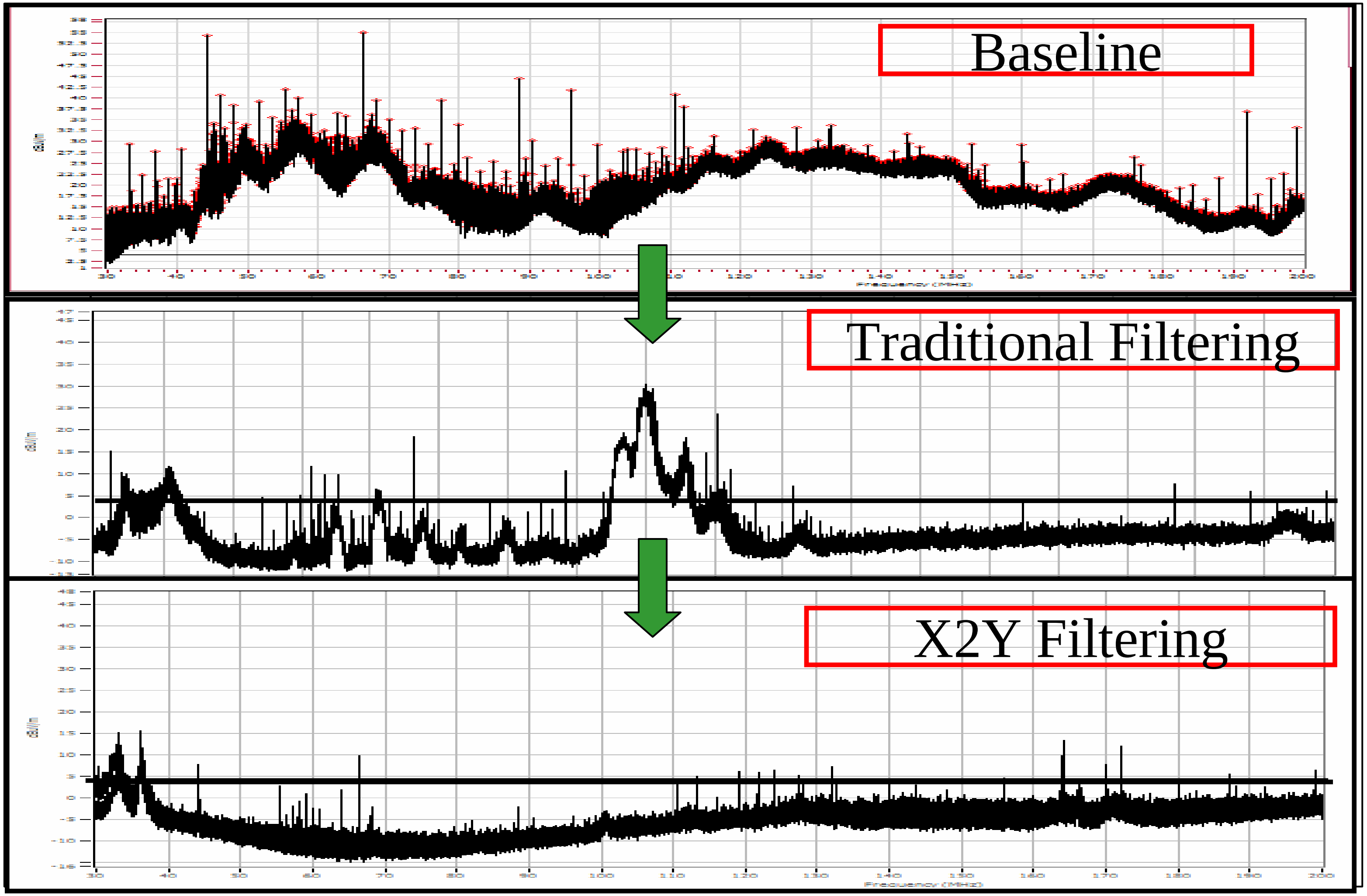


X2Y-Connector Implementation





Radiated Emissions with X2Y Filtering



Test Box Design

- Simple test boxes may only require traditional filtering approaches
- As complexity of electronics in the test box increases, more advanced filtering techniques may need to be explored and applied carefully
- Do not assume that a purchased unit off-the-shelf that is marked with the FCC, CE, IC, or E! will meet your approvals; additional filtering is usually required for automotive
- Ensure that design requirements are well understood before creating the test box; patches and installs done after the initial concept design can create EMC problems

Test Box Prove-out

- A thorough plan to evaluate the EMC performance of the test box must be considered
- The prove-out plan must be executed in advance of DV test execution and may include necessary revisions to meet design objectives
- During prove-out, it may be difficult to determine if the DUT or the Test Box is exhibiting failure
  - Unique troubleshooting methods need to be applied
  - Replace DUT with passive terminations
  - Place Test Box in the ‘DUT’ location and apply interference

Conclusions

- It is critical to have a proper EMC test plan defined prior to performing DV tests
- A support equipment prove-out plan should be executed prior to DV test and should be conducted in accordance to the defined EMC test plan
- Applied EMC filtering may negatively impact the communications or functionality of the support equipment; care should be taken to avoid this
- Significant improvements in EMC performance of the support equipment can be obtained through the use of traditional filtering along with advanced filtering techniques such as the use of the X2Y filtering component

Questions?

Thank You!

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