EMI TESTING

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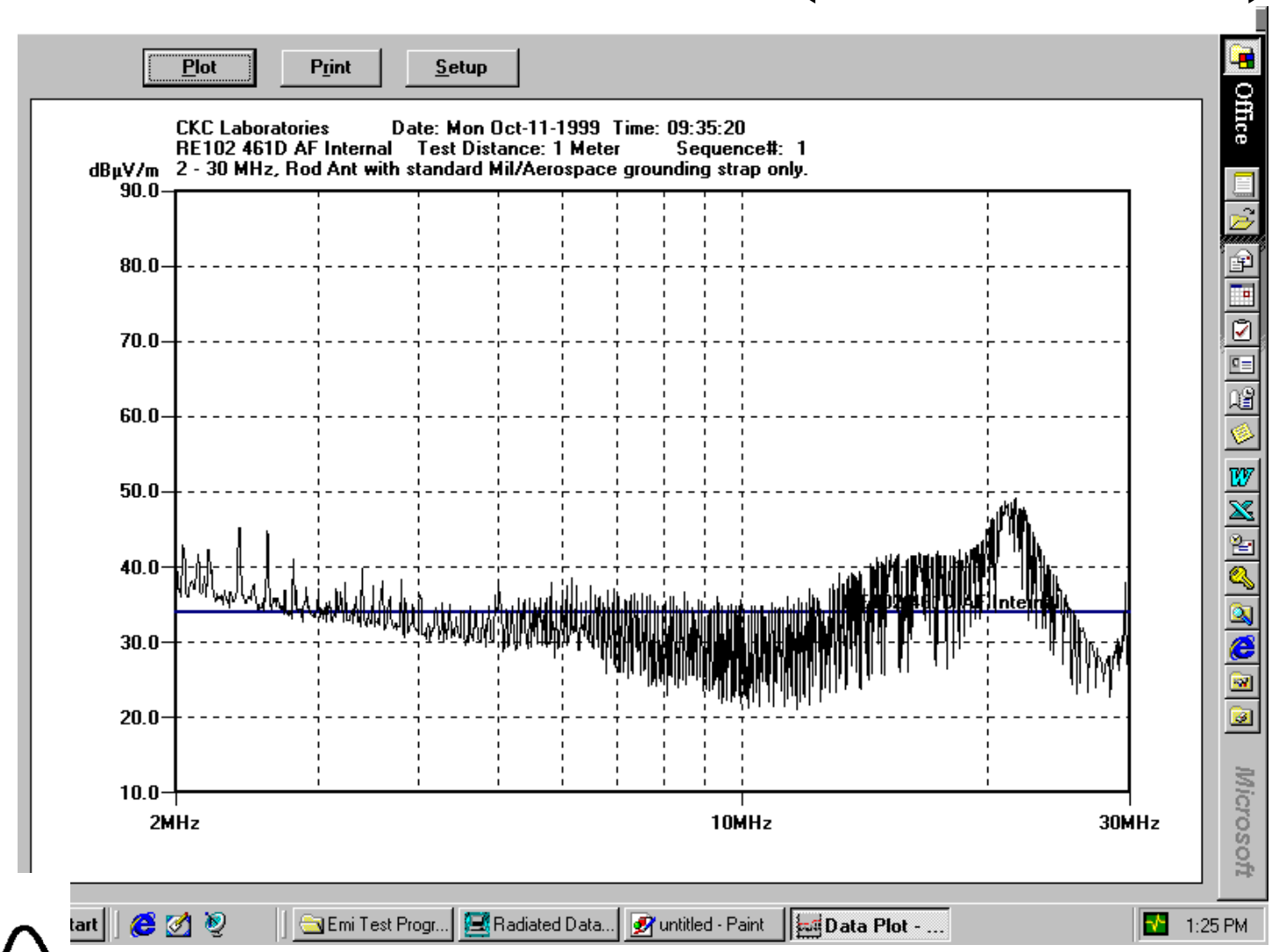
Sept. 26, 2005

ROD ANTENNA TESTING

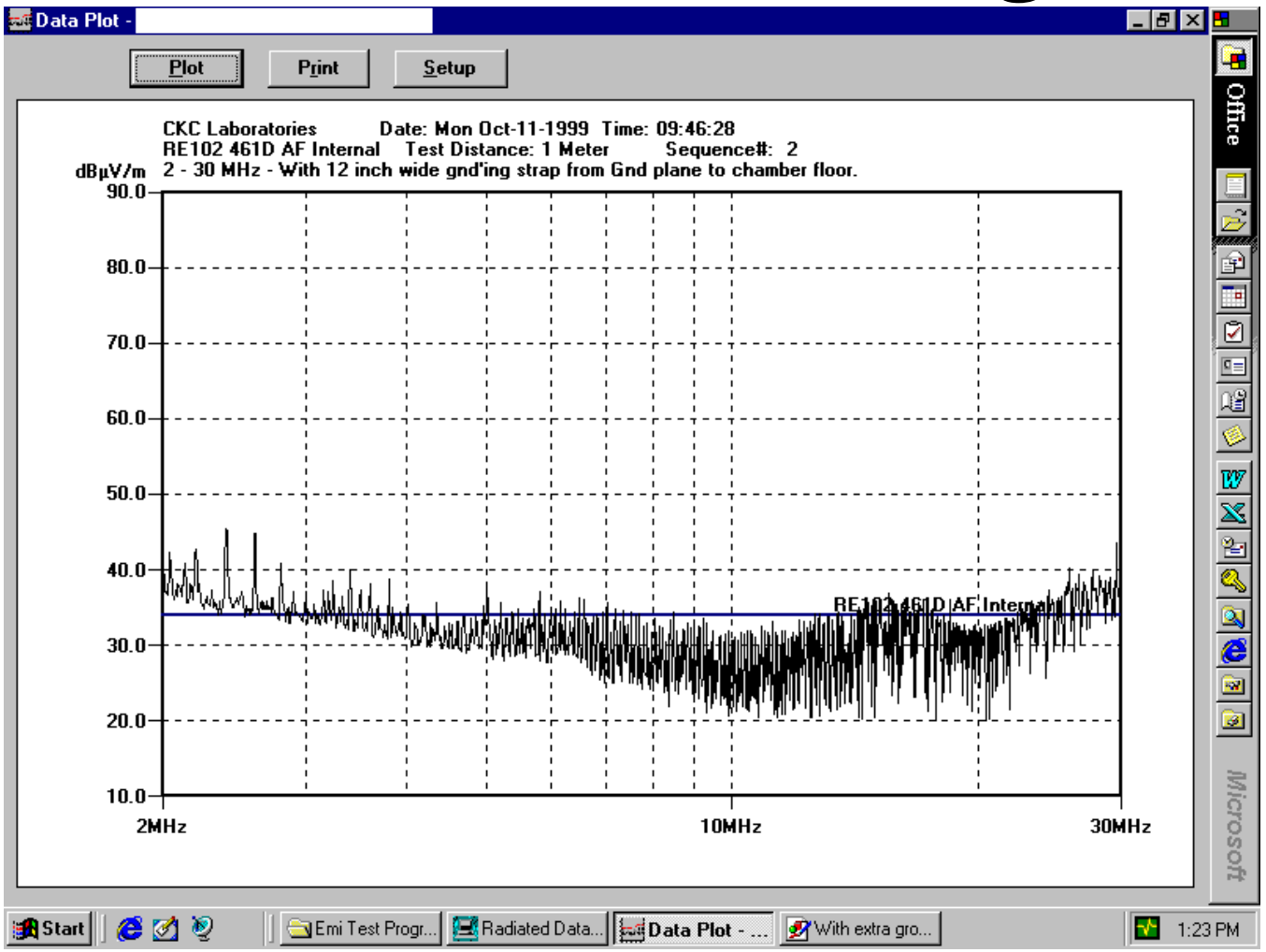
Complete article download from: http://stevejensenconsultants.com/rod_ant.pdf

- Applicable for DO-160 sec. 21 and MIL-STD-461 RE02/RE102 radiated emissions
- Problem: The 1-Meter long grounding strap, the copper ground plane bench, and the antenna ground plane form a parallel resonant circuit between 25 and 30 MHz typically
- Result: +15 dB added to results

Basic RE102 test (2-30 MHz)



RE102 with Foil w/rear gnd foil



Foil ground modified setup

Mechanically Vibrating Test Sample

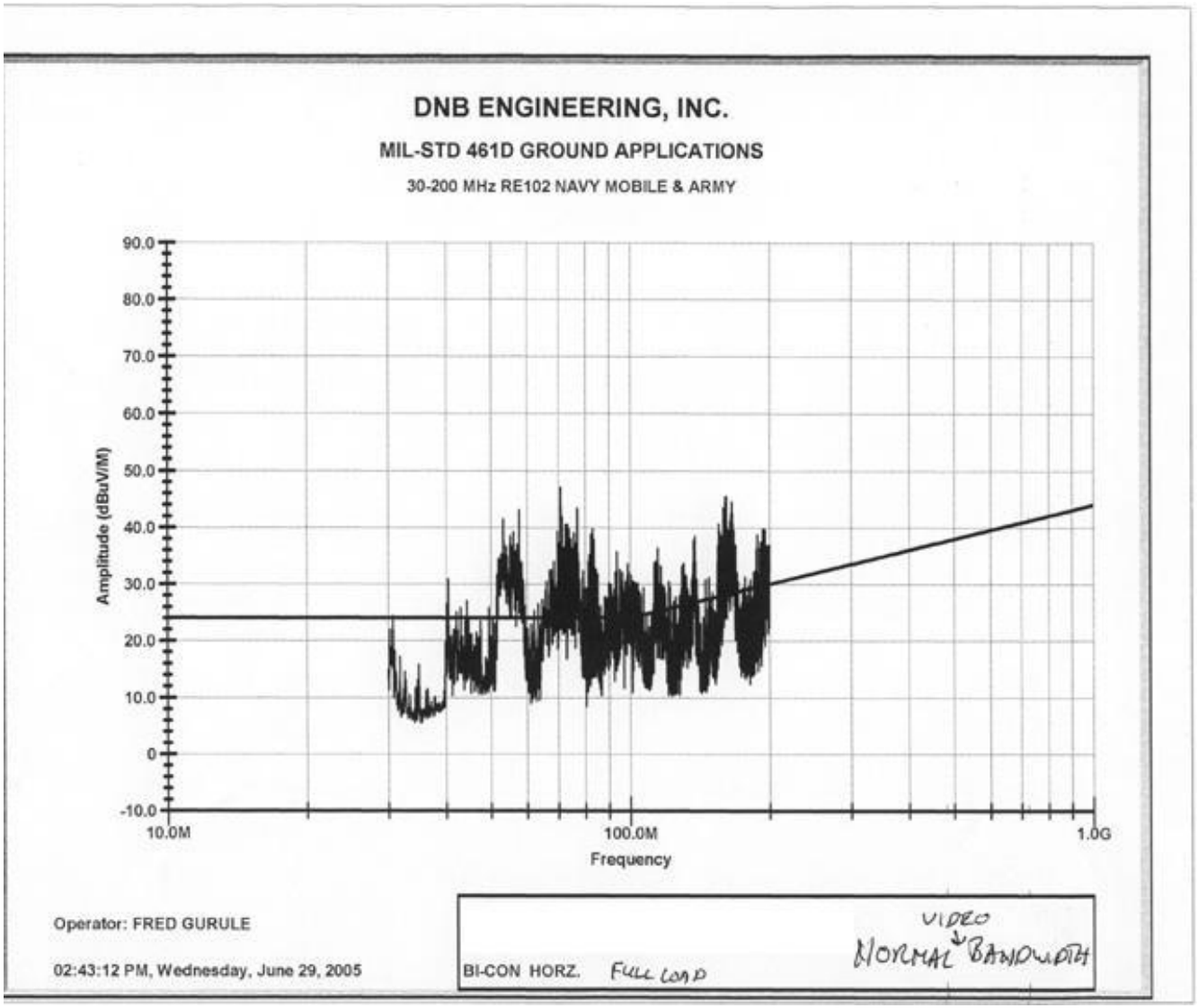
- Test samples such as engines vibrate and shake the shielded enclosure. The result is impulsive broadband random transient emissions that are typically above the RE102 and DO-160 RE limits using the specified bandwidths. ("Keychain effect")
- This effect is most pronounced in the rod antenna range (2 – 30 MHz).

Vibrating test samples (cont.)

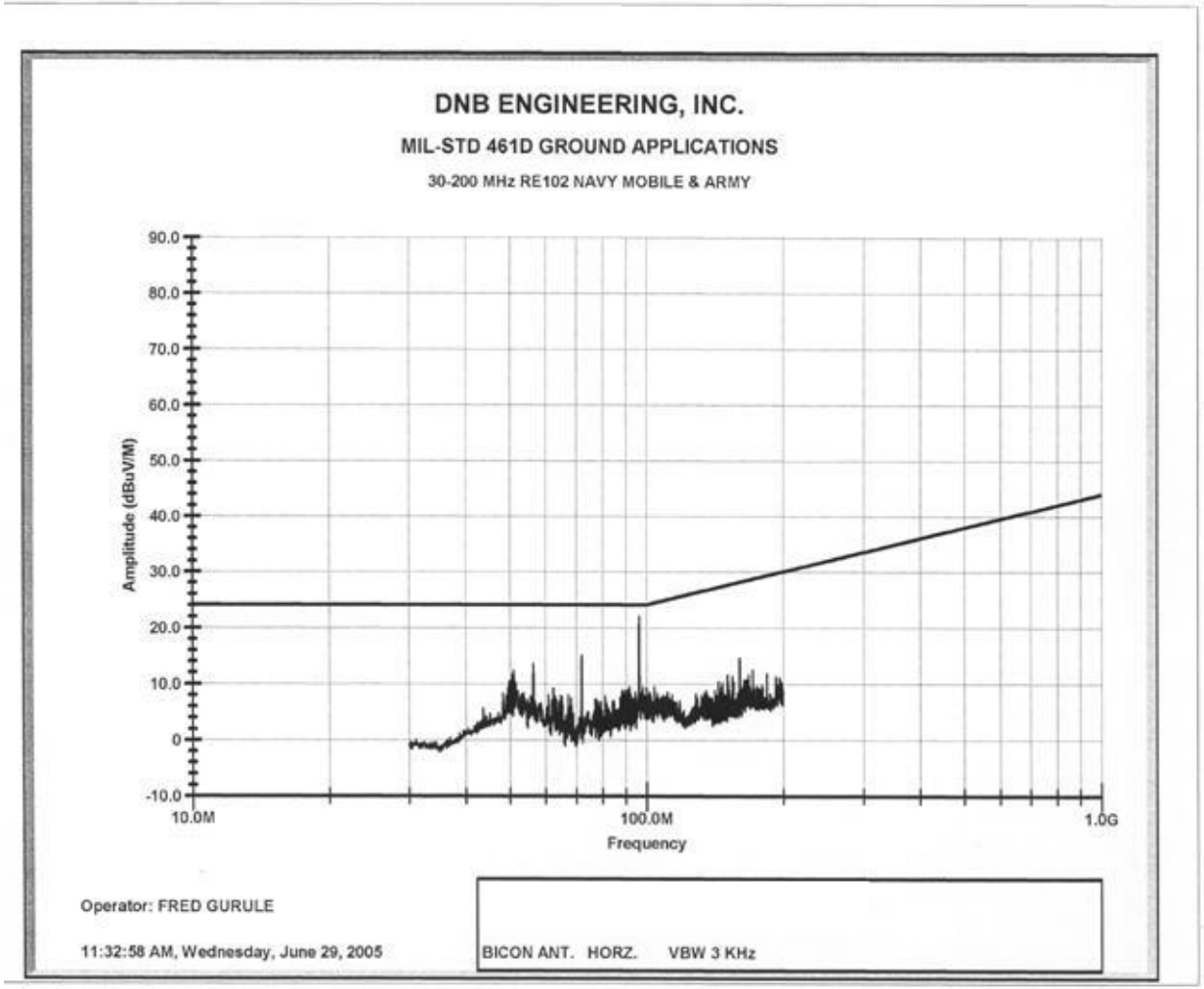
- Correction of the loose joints in the test facility or the test support equipment (I. E. exhaust pipes) is often not practical or possible.

- An observation is that the use of narrower than specified video bandwidths will exclude the random transients but still allow the steady state BB emissions that may be present from the EUT.

Reciprocating engine APU 461 100 kHz video BW RE102



Reciprocating Engine APU 100 kHz RBW, 3 kHz VBW RE102



Vibrating Sample Conclusions

- The reduced VBW has no effect on steady state BB or NB emissions that are present in the 461 specified RBW. In fact it exposed previously obscured NB emissions.
- At present, consultation with the procuring authority (461) is required to use this method.
- Increased dwell time is required to allow the detector to fully charge at each test frequency.

Conducted Emissions on Output Power leads

- DO-160 and the older version of MIL-STD-461(Rev A-C) require limits on conducted current on power supply outputs.
- The problem here is that power supplies are supposed to be characterized by low output impedance. The test requires measurements of current into very low RF impedances.
- These two facts are in conflict.

Conducted Emissions on Output Power leads

- The only technique for reducing current is to add series inductance which is counterproductive for the need for power supplies to have low impedance output.
- Addition of capacitance results in resonances with the test circuit wires and/or LISN's if used.

Output Leads Conclusions

- 461D/E corrects this problem - - No longer requires this test.

- For DO-160 use actual aircraft representative load instead of LISN's. This eliminates the resonances to the ground plane.

Relationship of Voltage on a short wire dipole to E-Field

8.) $$E_\theta = \frac{V L}{2 \pi \varepsilon |Z| \omega r^3}$$

And, $|Z| = X_o$

This simplified equation (8.) was used in the calculations presented for electric field emissions.

$$X_o = \frac{30}{\beta L}\left[-4 + 4 \ln\left(\frac{L}{A}\right)\right]$$

$$\beta = \frac{2\pi}{\lambda}$$

E-Field from a short dipole

(Full derivation in handout)

Where:

L= Length of dipole in meters

A= Diameter of the wire in meters

$\lambda = 3 \times 10^{8}/f_{Hz}$

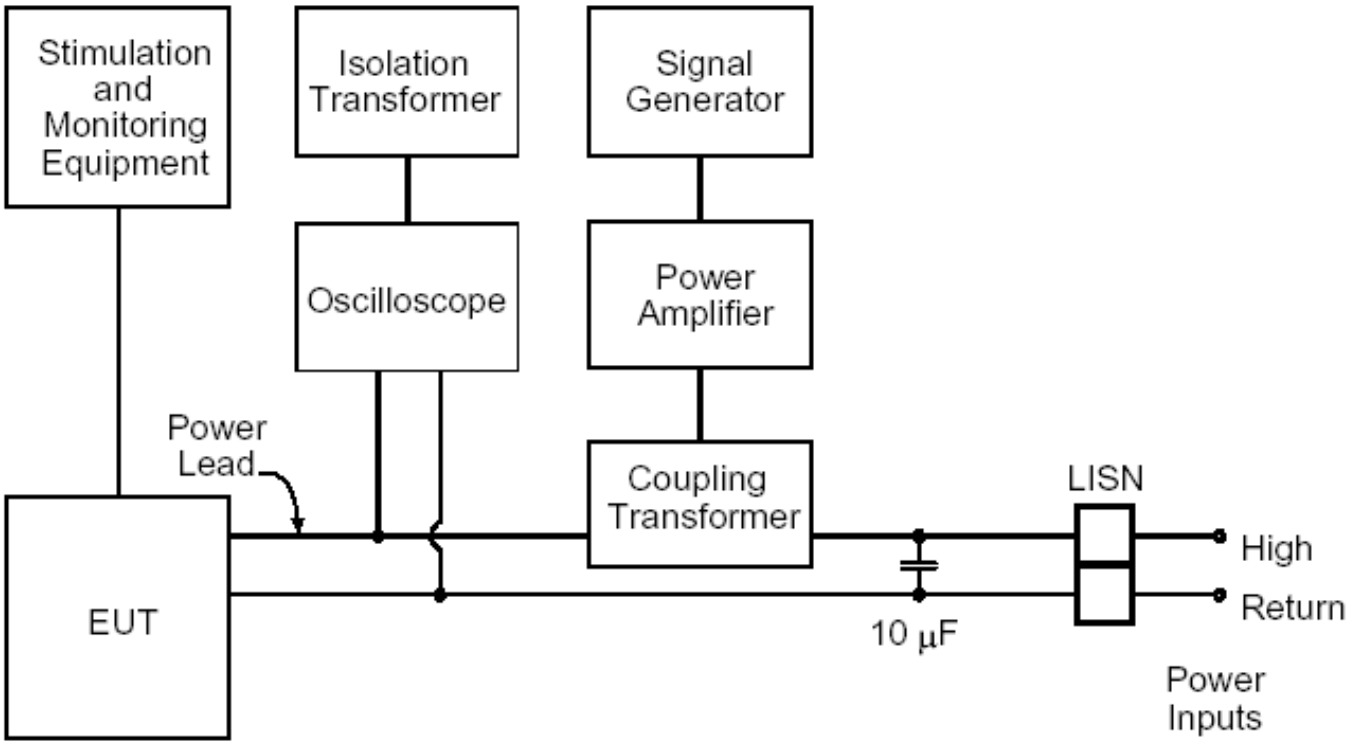
$\varepsilon = 8.842 \times 10^{-12}$

Example:

1 Volt RMS, 1 MHz on a dipole 0.1 meter long X 1 millimeter in diameter measured at a distance 1 meter from the antenna = 13.8 millivolts/meter field strength (83 dBμV/M)

MIL-STD-461D/E CS101

FIGURE CS101-4. Signal injection, DC or single phase AC.



MIL-STD-461D/E CS101

- Problem: 10 uF capacitor parallel resonates the two 50 uH inductors in the LISNs at 5 kHz.
- Result, at 5 kHz, the loop is open circuit essentially resulting in not being able to inject the required voltage to the EUT in and around 5 kHz.

CS101 Solution

- Use a computer grade electrolytic >10,000 uF for DC tests in place of the 10 uF capacitor.
- Use low impedance AC power supplies without the LISN for AC tests.
  - Note: The procuring authority must approve the test procedure with either of these setups. They are motivated however as the existing setup doesn't work.

Test Troubleshooting Tips

- For power lead CE, determine if predominate mode is common or differential at the frequency of interest.
  - Discussion
- For RE <200 MHz, the emissions are 99% likely to be from cables.
- Isolate the offending cable(s) by removing them if possible.

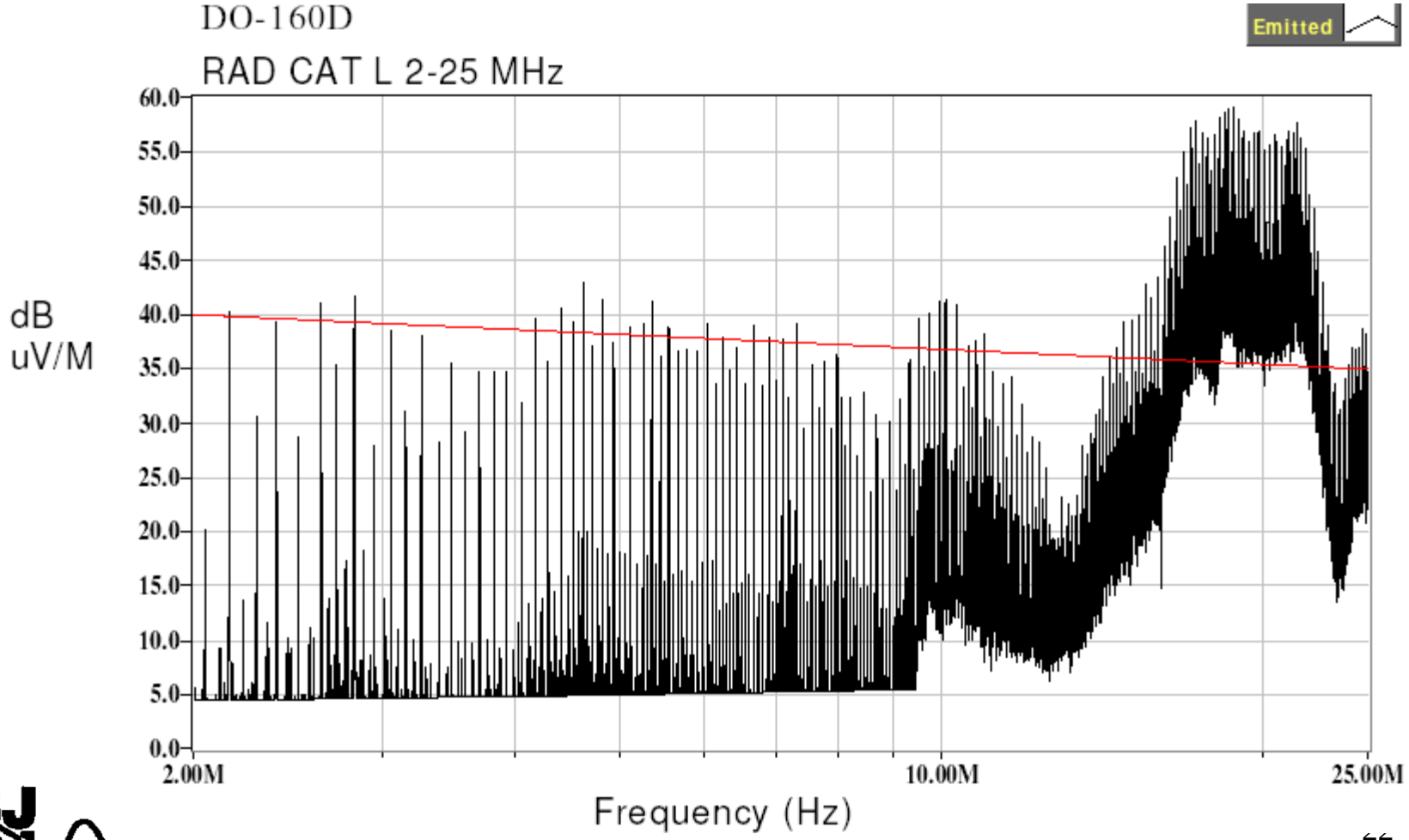
Test Troubleshooting Tips (cont.)

- For RE, make sure bench is grounded. The more grounding points for the copper bench, the less likelihood of spurious resonances related to the setup.
- Use “H” field sniffers instead of E-field when looking for case leakage or poor bonding at connector/shield interfaces.
  - E-Field sniffers have less resolution of leaks.

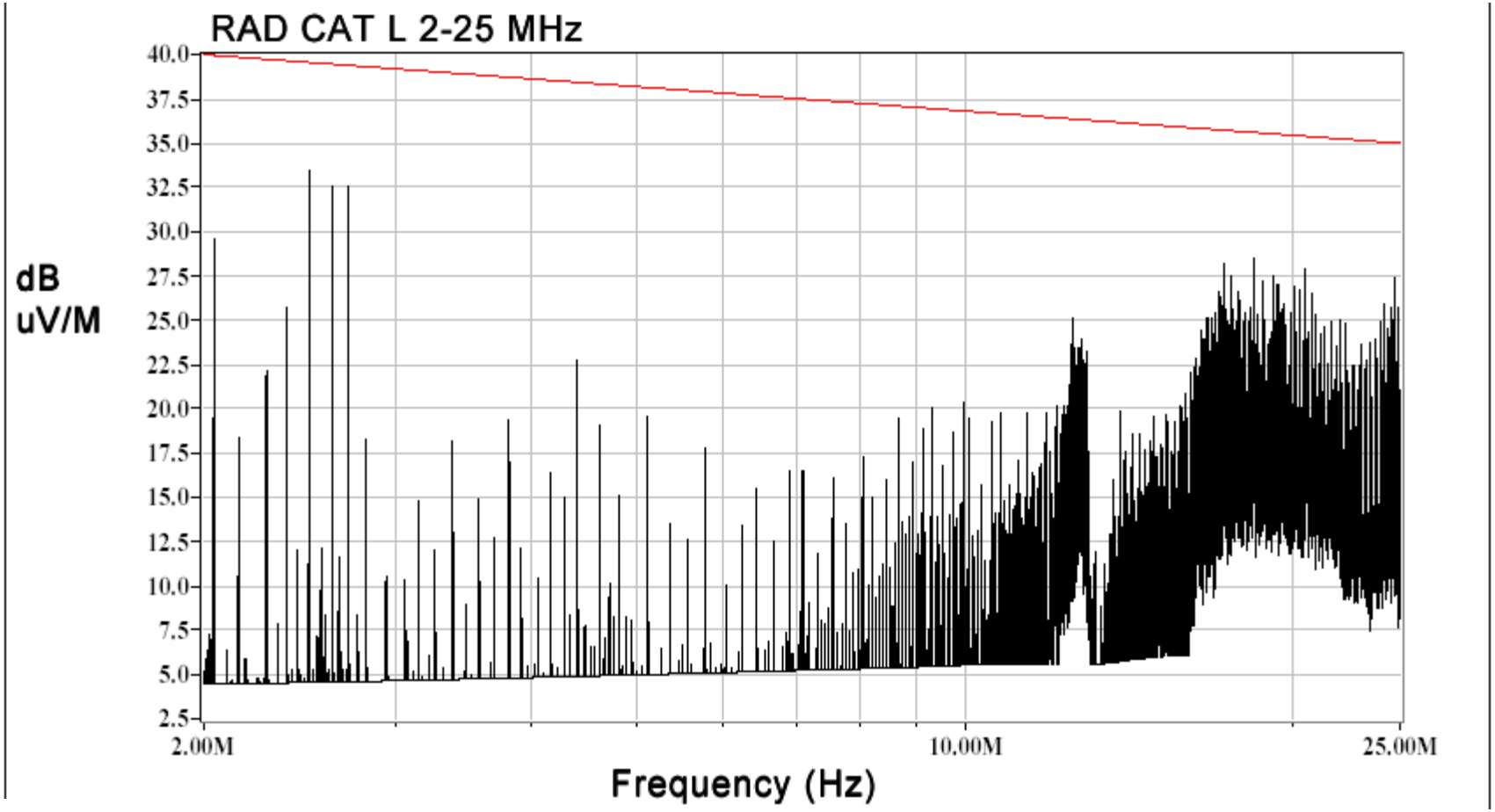
Design Tips

- Make sure I/O decoupling is physically immediately at the connector. Make sure decoupling components at connector are shielded from the rest of the assembly. Follows is an illustration on the effect of simply shielding the area around a filter board assembly at the connector.

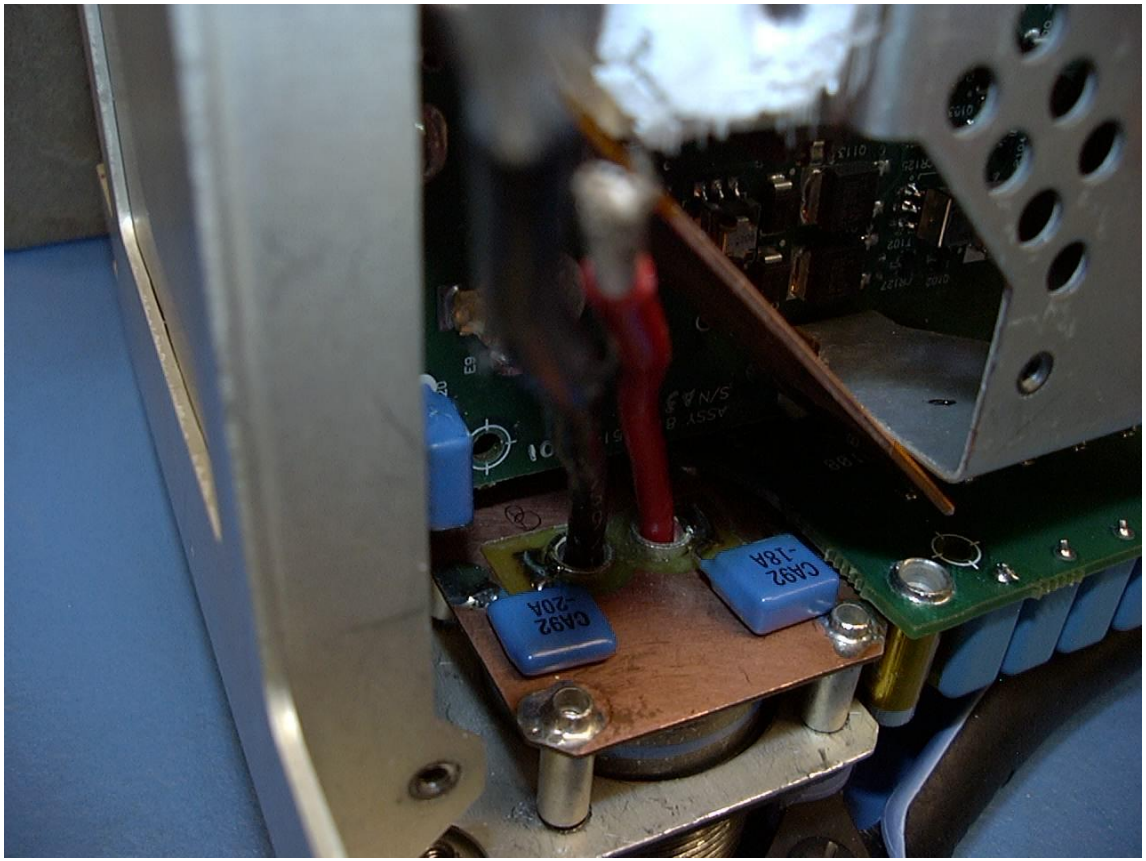
RE without shielding at I/O filter



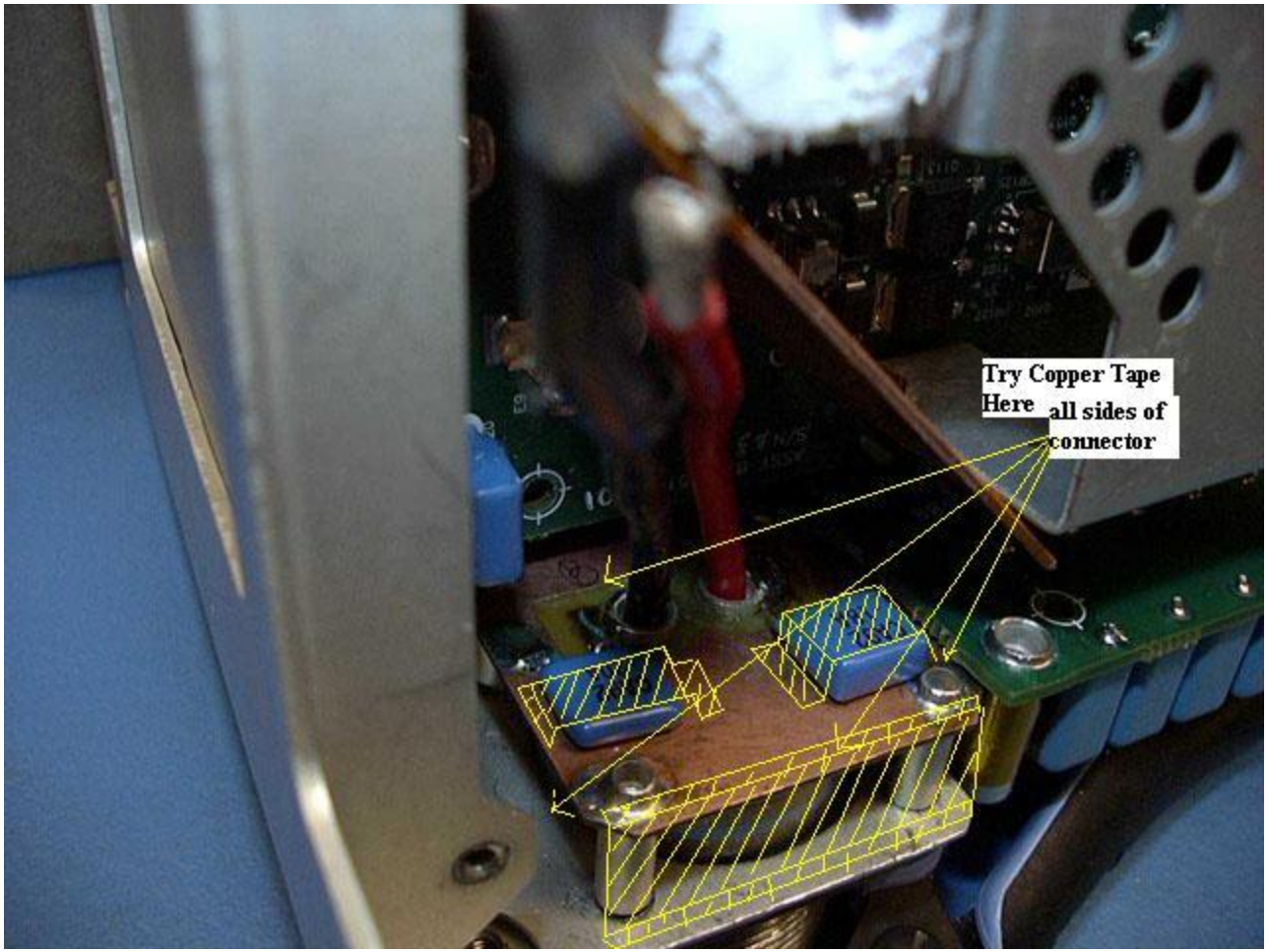
RE w/shielding of I/O filter



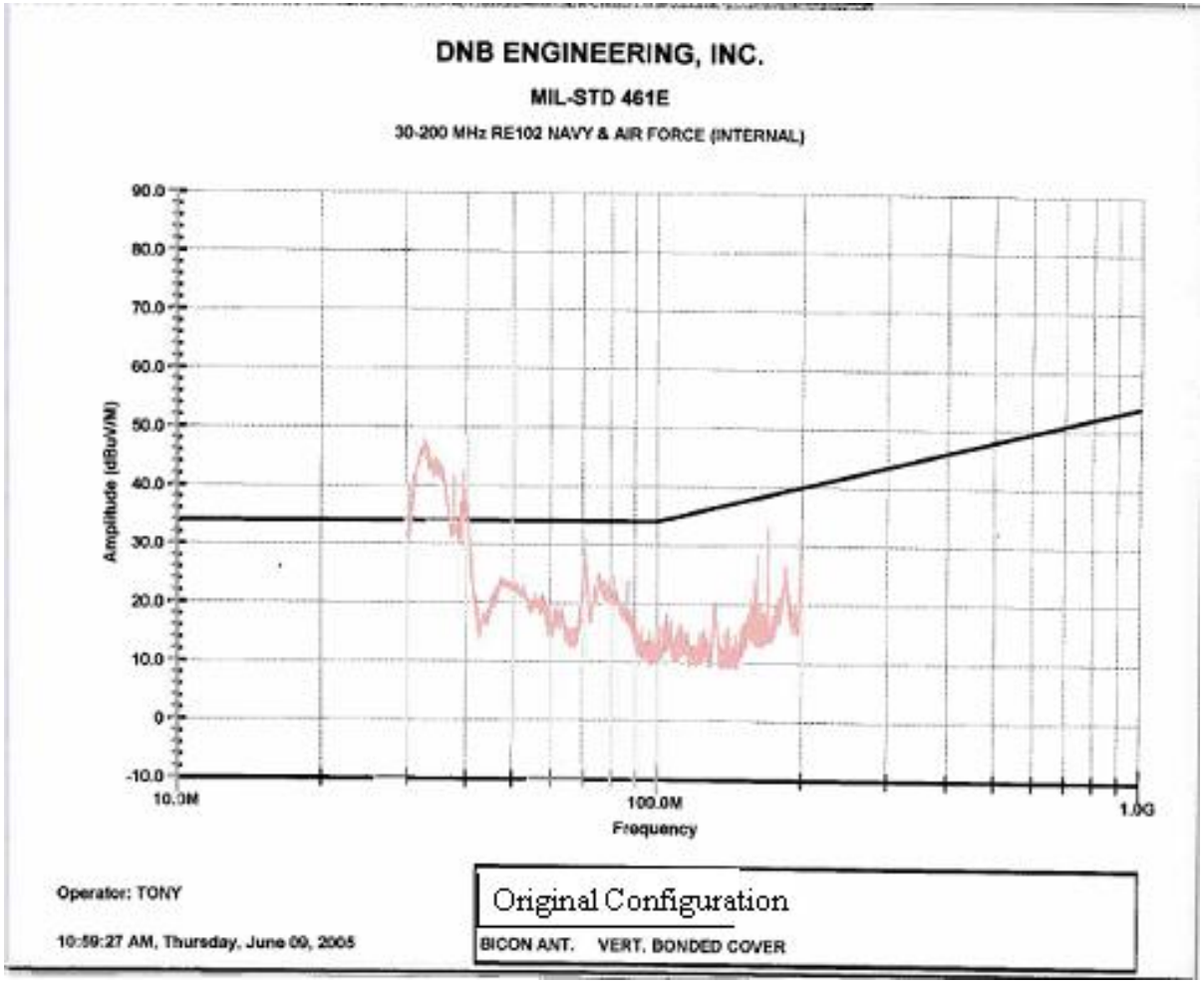
I/O Filter assembly



Shielded I/O assembly

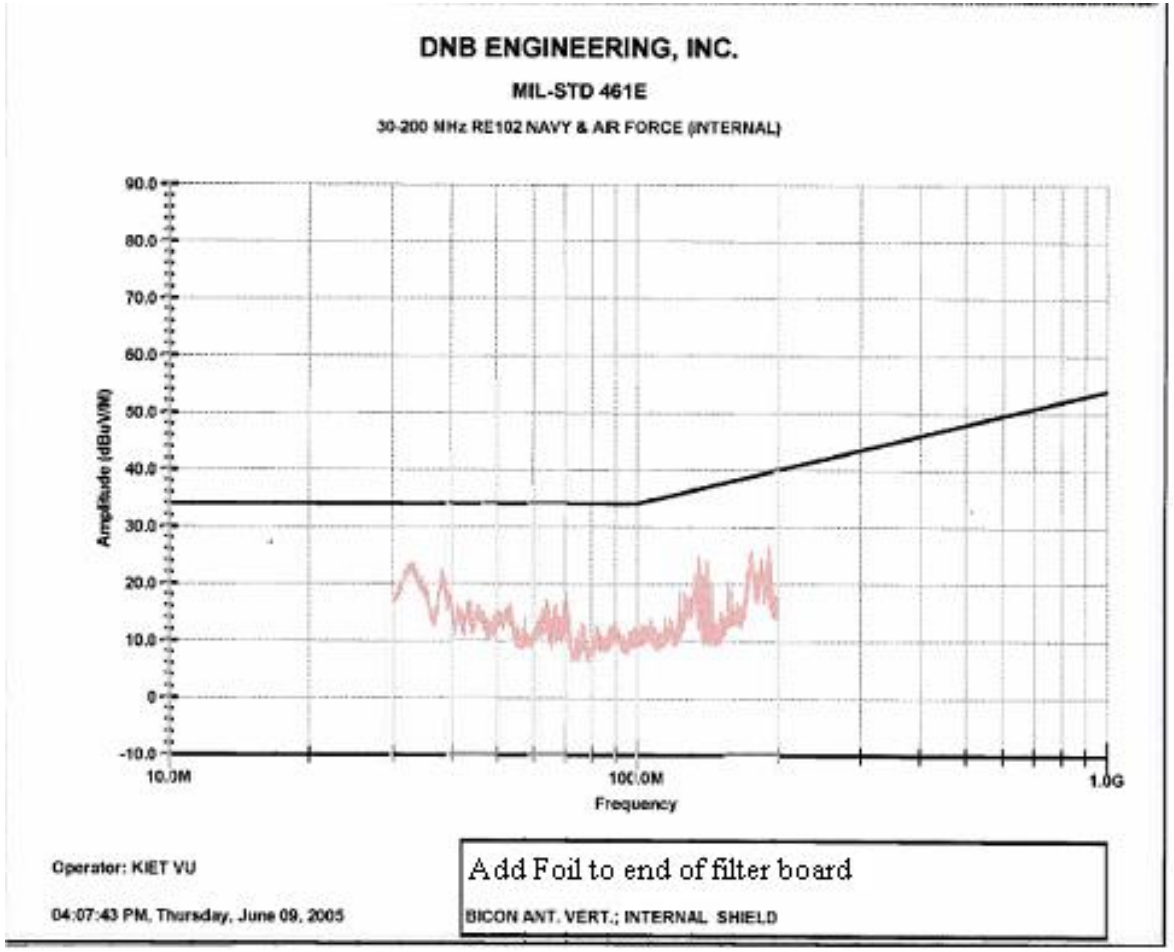


Another Example (I/O shielding)



I/O Photo

RE Data w/shielded filter

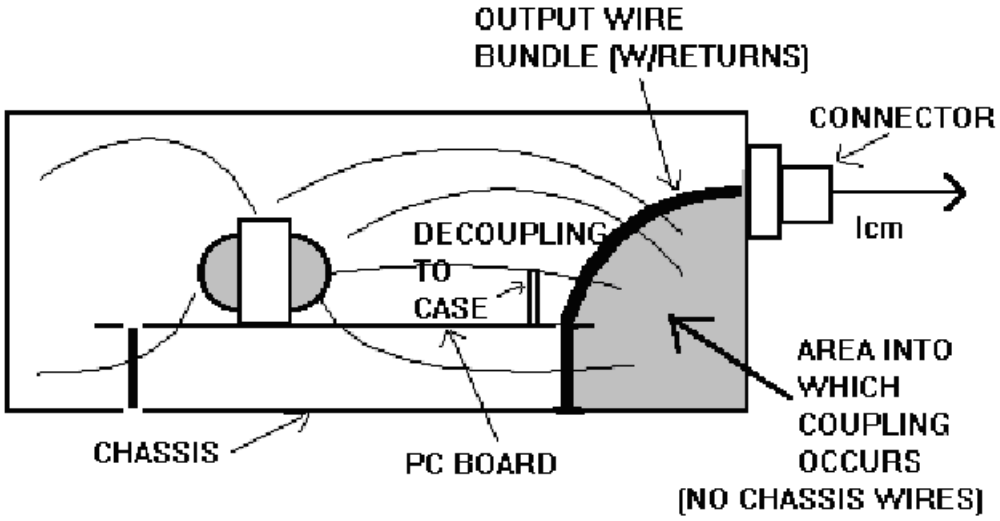


Design Tips (cont.)

- DO-160D/E and 461 (Rev A-C): Use inductive input filters and R/C dampers at power input to eliminate resonances in the test setup
  - Discussion
- MIL-STD-461D/E: Capacitive input filters are good. Test setup resonances not an issue for CE tests
  - Discussion

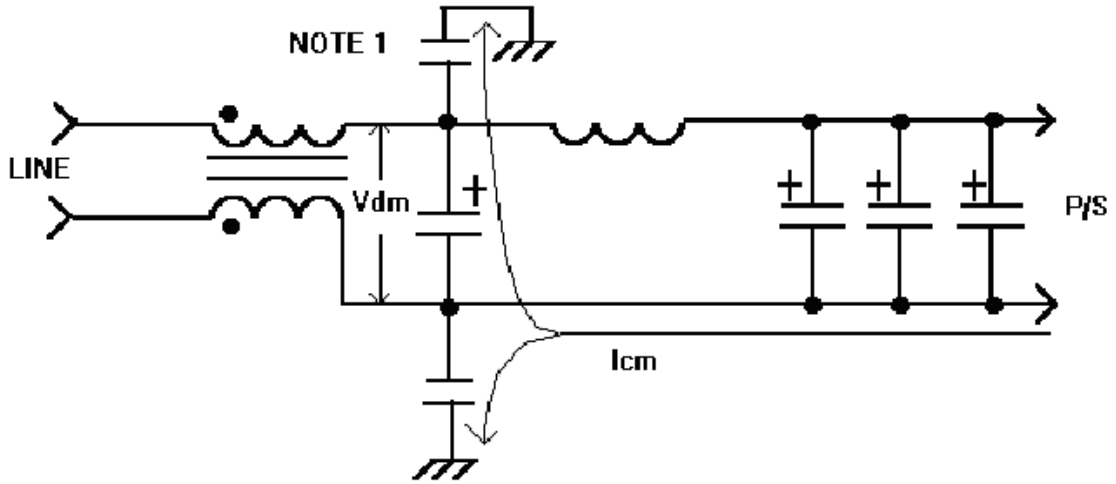
Design Tips (cont.)

- "Chassis wires" are effective for loop area control at both I/O and power input areas.
  - Discussion



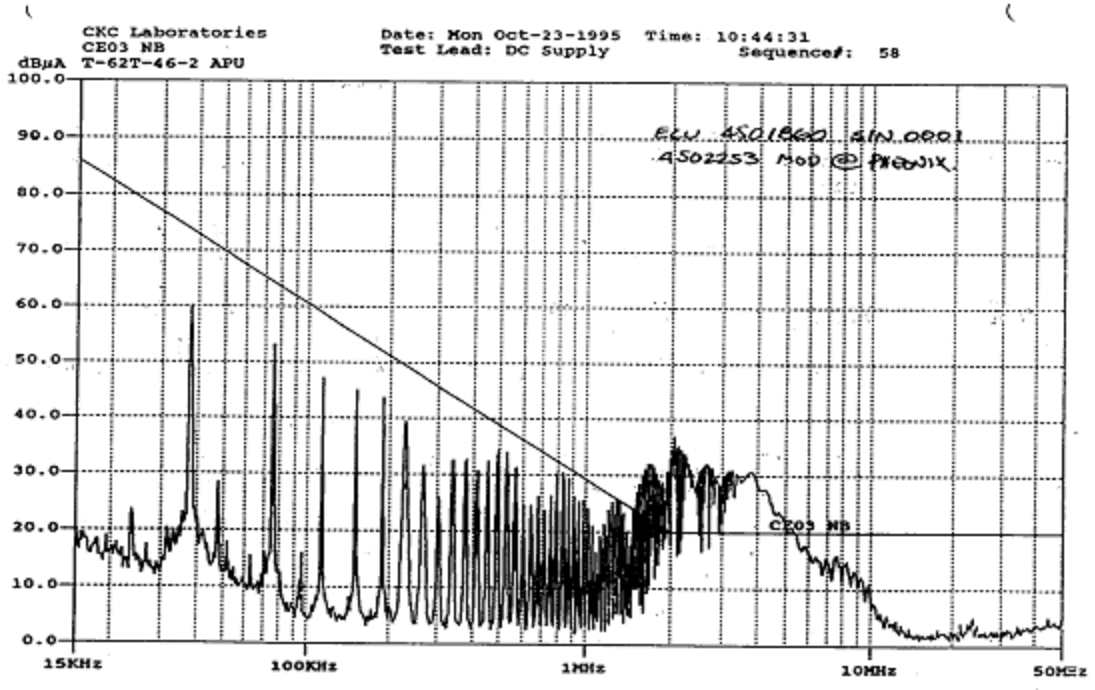
Design Tips (cont.)

- Avoid asymmetrical power input filter circuits.

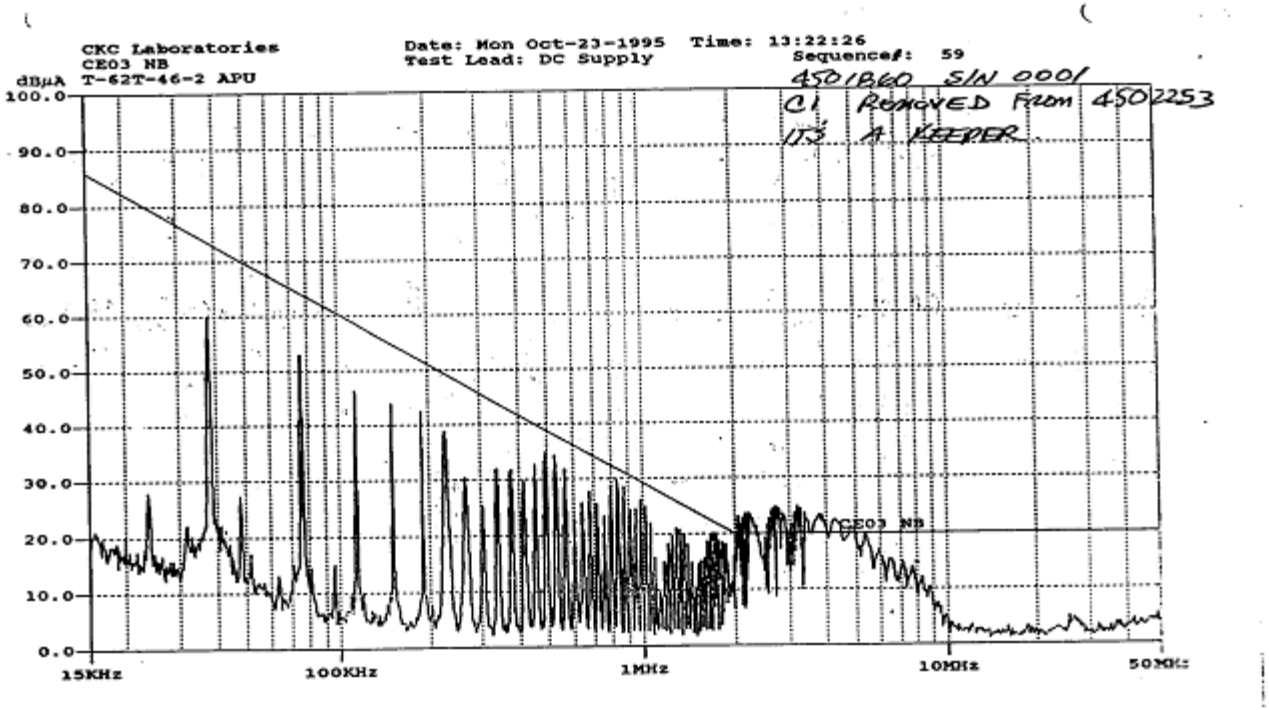


NOTE 1: TAKE THIS CAPACITOR OUT AND IT WORKS BETTER

Data with capacitor



Data w/o capacitor



Design Tips (cont.)

- Filter topology
  - Locate baluns (cm chokes) as first elements (next to power input) in filters
  - Use bifilar winding on CM chokes instead of sector or “pi” winding. (leakage inductance is less by a factor of 100 typically)
  - Do not place line to line capacitors directly across the load side of a CM choke. (Creates a DM resonance)

Design Tips (cont.)

- Evaluate damping (resonances) in filters where audio CS tests are required.
- Remember to include test setup (LISN or 10 uF capacitor) in equivalent circuit of filter
- Use design tools for filter design
  - Discussion, PSpice etc.