

COMPARISON OF AUTOMOTIVE UNIT EMC TEST TECHNIQUES

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Abstract

A comparative assessment of the test methods for both immunity (BCI, TEM, stripline, free field) and emissions (free field, stripline) testing as applied to automotive electronic modules has been made. The results illustrate significant differences between the various test methods due to resonance's within the test system and with the unit under test (UUT or ECU), however, over the majority of the test spectrum the different methods offer a reasonable degree of cross-correlation to their idealised operation.

Test Methods.

Radiated emissions and immunity.

Radiated tests are normally done in an anechoic chamber (see figure 1). This is a screened room lined with material that absorbs radio frequency energy. This absorber is typically carbon filled foam in pyramid shapes attached to the walls and roof of a metal room. A typical test set-up is shown in figure 2. The aerial (shown here as a horn antenna, compared to the log-periodic biconical in figure 1) is connected to a receiver for emissions measurements, or connected to a radio frequency power amplifier and signal source for radiated immunity testing.

The test set-up shown is typical, it consists of the unit under test "UUT" (top right in figure 2), connected via a wiring harness (loom) to a simulator ("Sim" top left in figure 2). A LISN (also called an Artificial Network, AN) is also present (top left). This ensures the UUT sees a well defined impedance on its power leads (for automotive testing normally a 5uH/50 Ohm AN is used).

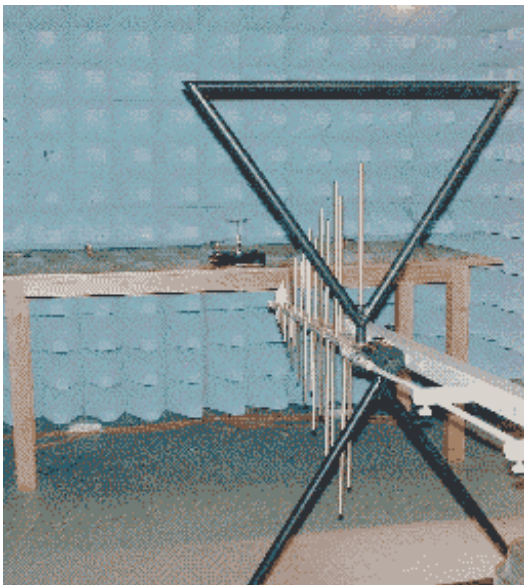


Figure 1 - inside of an anechoic chamber showing absorbing cones.

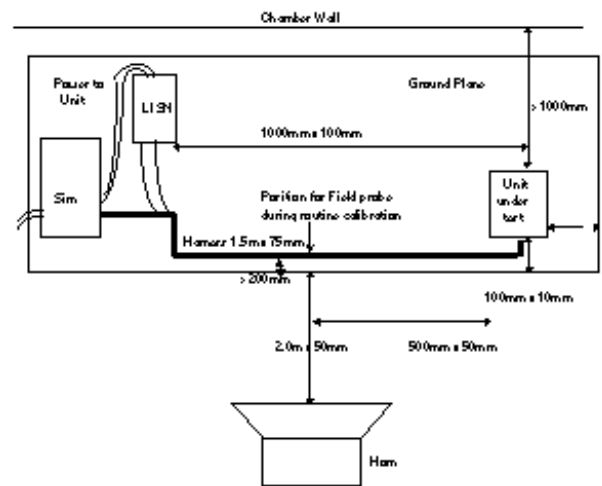


Figure 2 - typical radiated test set-up

The emissions levels allowed by Law in Europe (ref. 1) are shown in figure 3.

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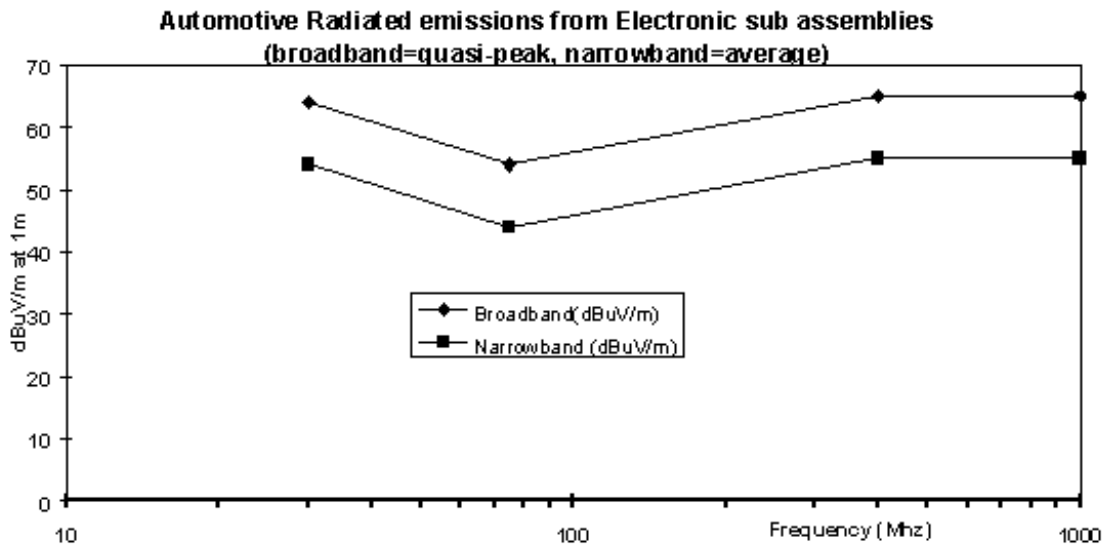


Figure 3, European Directive 95/54 radiated emissions limits.

Stripline

This is another radiated immunity test technique (that can also be used for emissions). Rather than use an aerial and anechoic room, the field is generated between two parallel plates (normally with 150mm separation). The “plates” are the large rectangular area between the two end “triangles” in figure 4. This technique is considerably more efficient at generating a radio frequency field - mainly because of the closeness (150mm spacing of plates rather than 1m separation of the aerial). Because of this it is commonly used.

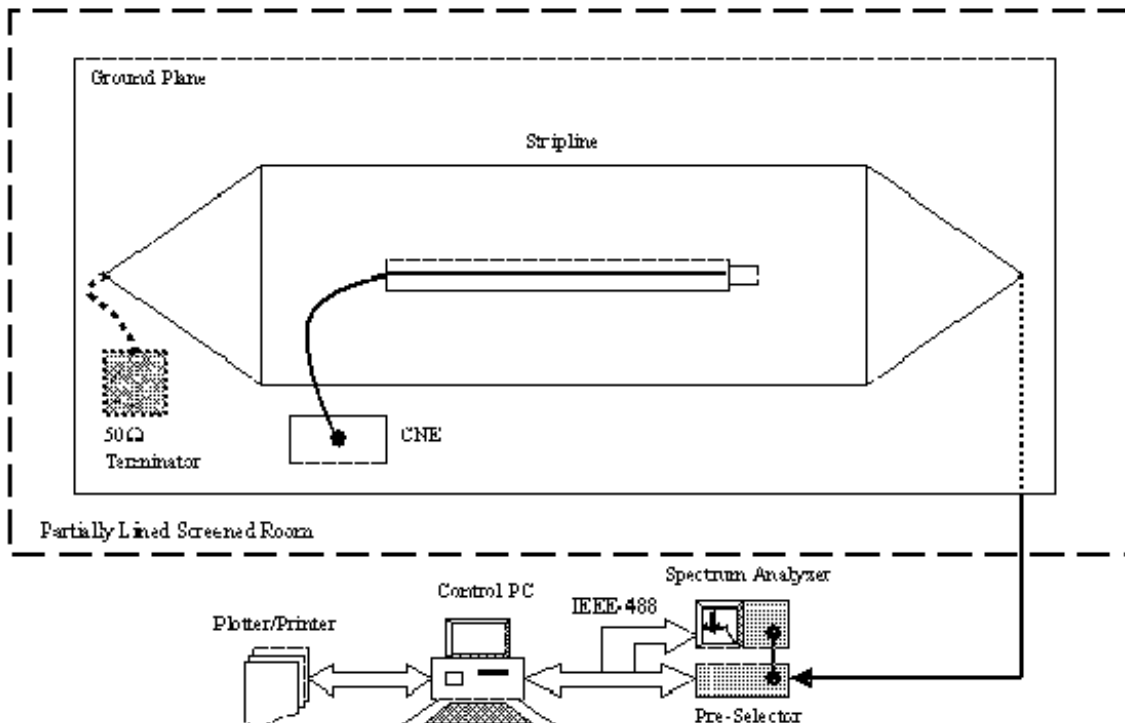


Figure 4 - typical stripline set-up (shown setup foran emissions test to CISPR-25 Annex B).

TEM cell.

A TEM cell (also called a Crawford cell), can be considered as a small screened room (for example 54*26*26 inches) with an inner plane dividing the cell into two identical parts with the “pointed” ends providing a good match to the 50 Ohm

source (and the load with is not shown in figure 5). This plane is electrically isolated from the outer walls (which are grounded) and is coupled to the inner conductor of the feed coax. The unit under test is placed in between this plane and the bottom of the cell with (short) leads connecting to loads etc outside the TEM cell. The TEM cell is thus a close relative to the stripline, but has the advantage of being fully enclosed (and so can be used outside of a screened room) and the disadvantage that its size means only a small amount of loom (leads) are normally inside the cell.

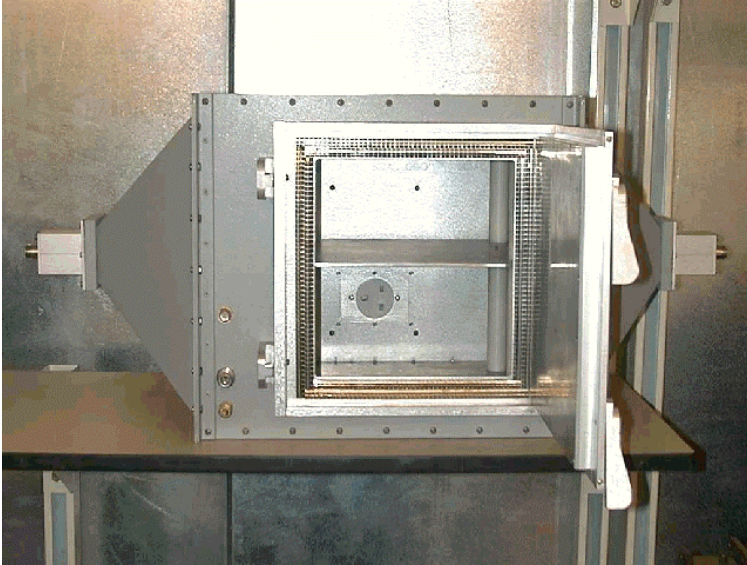


Figure 5 - typical TEM cell set-up.

Bulk current injection

This is another technique for radiated immunity testing that is often seen. It effectively uses transformer action to directly inject current into the loom. The injection probe is a toroidal transformer and the loom makes a “1/2” turn secondary “winding” by being passed through the hole in the centre of the probe (see figure 6). Because of the “direct” nature of Bulk Current Injection (normally called just BCI) it is also very efficient at coupling energy into the loom. This approach can also be used in reverse to measure the current in the loom (a “conducted” radiation test). Conducted emissions tests are detailed in standard CISPR25.

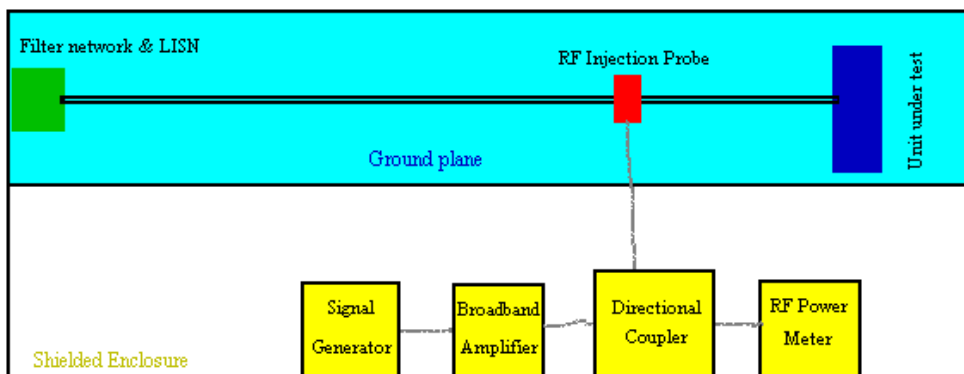


Figure 6 - typical Bulk current injection test set-up.

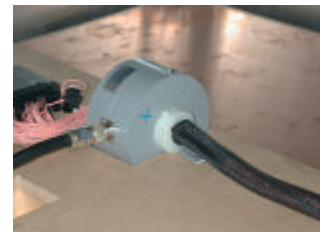


Figure 7 - BCI injector probe

Comparison of Immunity test methods

European directive 95/54 requires testing between 20MHz and 1GHz with the following test limits for automotive electrical modules that are involved in direct control of the vehicle:

- 48V/m for 150mm plate separation stripline (ECU 200+/-10mm from edge of stripline).
- 12V/m for 800mm plate separation stripline (ECU and part of loom under stripline).
- 60V/m for TEM cell (ECU and small bit of loom in cell).
- 48mA for bulk current injection (calibrated via a standard calibration jig, probe 150+/-10mm from each connector of the ECU, instrument module or active sensor).
- 24V/m for “free field” testing (ECU must be at least 1m from antenna).

In practice the levels given in 95/54 are not exactly equivalent over the whole frequency range. Figure 8 shows the equivalent free field v/m for BCI, it can be seen that BCI provides a much harsher test at low frequencies, while free field testing may be harsher at high frequencies (the general 2:1 correspondence assumed in 95/54 can be seen to be reasonable over most of the frequency range).

Similar comparisons can be drawn with the stripline and TEM cell see figures 9 and 10. The main features of the curves in figures 8,9,10 can be explained by resonance's in the test set-ups.

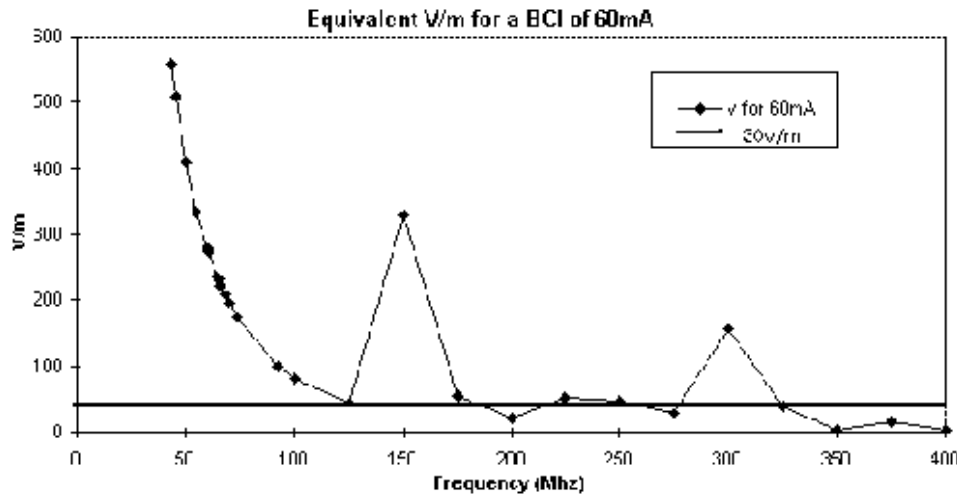


Figure 8 - Comparison of BCI and free field radiated immunity levels.

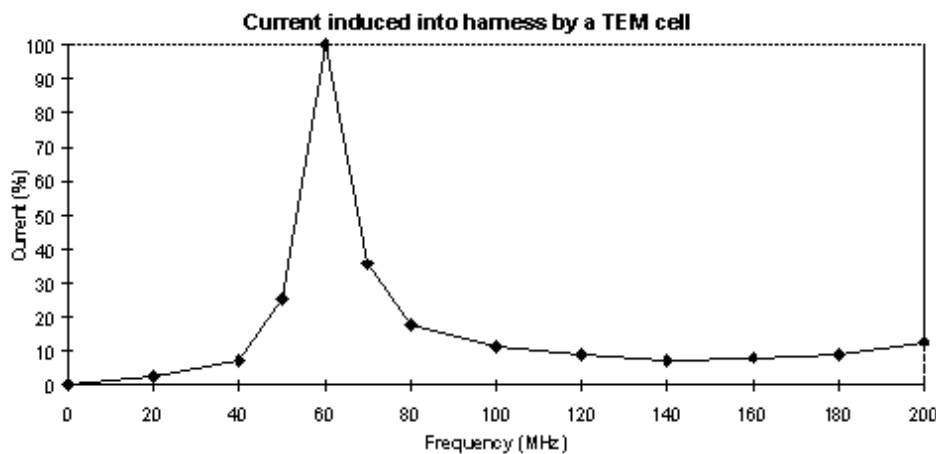


Figure 9: Typical current induced into a harness by a TEM cell.

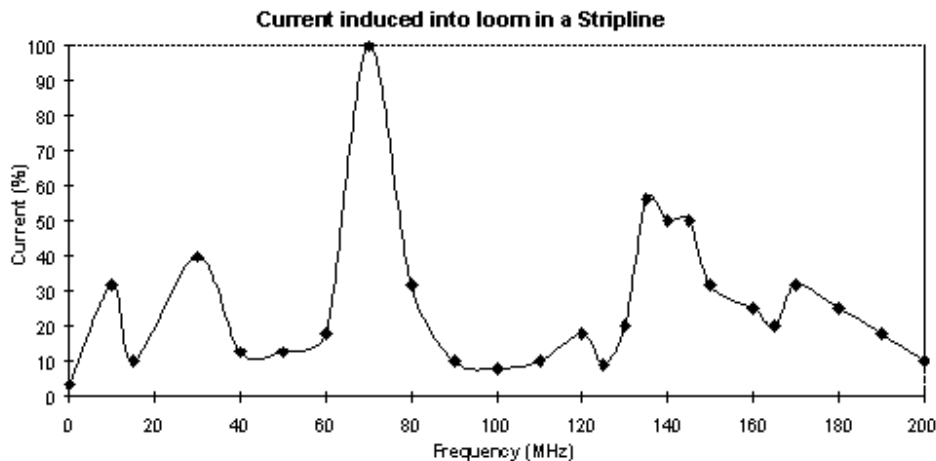


Figure 10: Typical current induced into a harness in a stripline.

Comparison of Radiated Emissions Test Methods

Most automotive module radiated emissions tests are conducted in a semi-anechoic chamber, using the test set-up shown in figures 1,2. CISPR-25 annex B [ref. 3] describes a “test harness” (see figure 11) that is useful for comparing different emissions measurement approaches. This test set-up approximates that used when measuring real devices, but the UUT is replaced by a wideband noise source (CNE) and the LISN/Simulator (see figure 2) is replaced with a 50 Ohm termination.

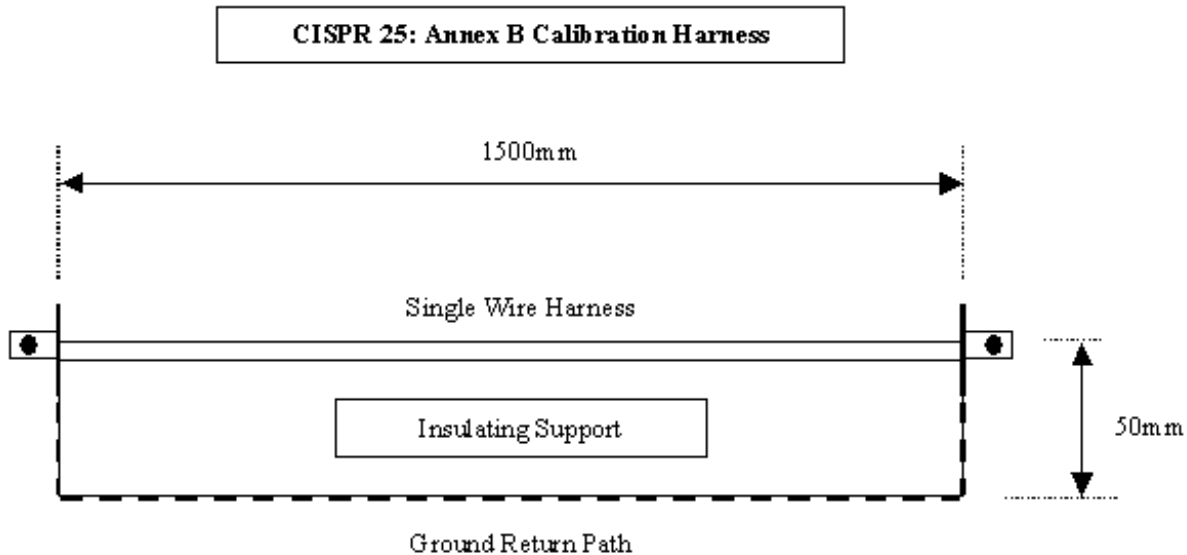


Figure 11: CISPR 25 annex B calibration “harness”.

Figure 12 shows the emissions of the emissions source of figure 11 as measured in a semi-anechoic chamber (in dBuV/m) and as measured in a stripline using the test set-up of figure 4 (in dBuV). It can be seen that over a wide part of the frequency range (~40MHz to 400MHz) the results are broadly comparable. It should be noted that the stripline measures approximately the total radiated power from the harness, while in the semi-anechoic chamber the antenna measures only the radiation within the direction of the (3D) “beamwidth” of the antenna used.

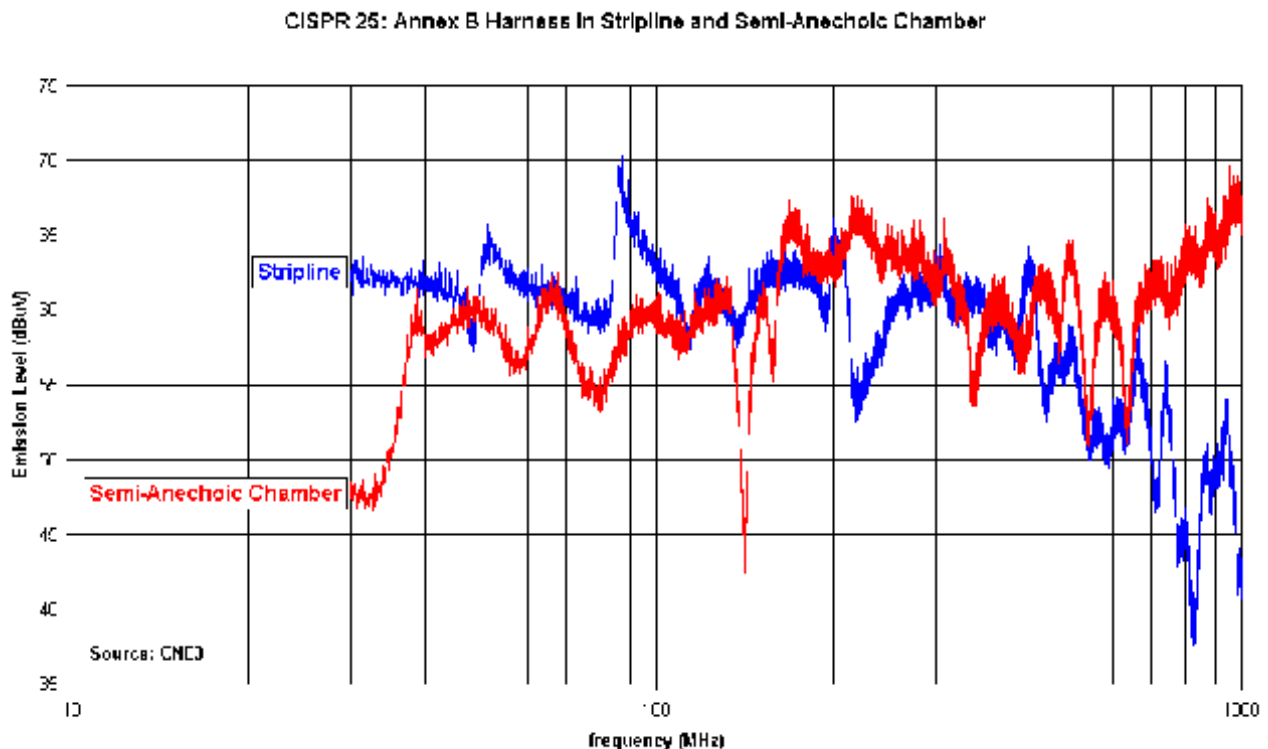


Figure 12: Emissions from CISPR-25 Annex B harness fed with a CNE as measured in a stripline and a semi-anechoic chamber.

Conclusions

This paper has briefly described the automotive EMC test methods normally used for electronic modules. It has also compared the immunity & emissions test methods and shown that the techniques used may give different results when testing an identical module. It should also be noted that all vehicle manufacturers have their own EMC standards (see for example ref. 9).

References

- 1) Commission Directive 95/54/EC of 31st October 1995 - "the Automotive EMC Directive"
- 2) "EMC for Product Designers", Tim Williams, Newnes, 2nd ed 1996.
- 3) CISPR25 "Limits and methods of measurement of radio interference characteristics for the protection of receivers used on board vehicles".
- 4) ISO7637 parts 1,2,3 "Road vehicles - electrical disturbance by conduction and coupling".
- 5) ISO11451, "Road vehicles - electrical disturbances by narrow band radiated electromagnetic energy: vehicle test methods".
- 6) ISO11452, "Road vehicles - electrical disturbances by narrow band radiated electromagnetic energy: component test methods".
- 7) "Bulk current immunity testing, its advantages and disadvantages for Automotive EMC testing", P.Miller, Proceedings Autotech 95.
- 8) "A study of distributed load dump suppression for motor vehicles", P.Miller, Proceedings of Autotech 97.
- 9) "Automotive transients - the Ford approach", P.J.Page, IEE Colloquium "Automotive transients", 16-12-96.