

WIRED OR CHASSIS GROUND: THE BEST SOLUTION FOR AUTOMOTIVE EMISSIONS

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ABSTRACT

Investigations into the level of radiated and conducted emissions from an automotive electronic sub-assembly (ESA) given either a chassis grounded case or a wired ground return have been examined using standard cables and a comparison noise emitter as a simulated ESA. The cable harnesses used have been the standard 1.5m length required for 95/54/EC and CISPR-25 for radiated emissions and 0.2m for CISPR-25 conducted emission tests.

The results have been previously released as comparison of the effect of harness length variations on different automotive test standards [1,2]. Here the results have been examined specifically to determine if using a wired ground return or a chassis ground return offers any benefit with respect to emissions performance.

INTRODUCTION

The automotive OEM usually defines the harness used in a vehicle and the supplier of any electronic sub-assembly (ESA) has little control over construction, length and even connector used. The one area where the ESA supplier may have an influence is the route for the current return (ground); either via a wired connection on the harness or in the situation of a metal enclosed product, via the vehicle chassis. Often a metal bodied ESA will use the chassis return and utilise the metalised ground enclosure for screening of the internal electronics.

The main problem with chassis grounding is maintaining the reliability of the ground throughout the life of the vehicle. I expect most readers have followed an older vehicle that has had ground return problems, in particular when a vehicle has switched on the turn-indicator and the rear lamp cluster flashes all its lamps synchronously with the turn indicator. Not a major EMC problem for such simple functions, but what would happen with a poor ground on an ABS system or engine management unit (EMU)?

This paper examines the impact of returning the ground current either via a chassis return or

wired return on the conducted and radiated emissions obtained during automotive EMC testing. Following the results on EMC testing the discussion examines the likely impact this will have in-vehicle and whether or not chassis or wired return provides any benefit with respect to automotive ESA emissions performance.

AUTOMOTIVE EMISSIONS TESTING

Generic ESA

A comparison noise emitter (CNE) was used in place of a real ESA to avoid issues with impedance matching as well as commercial sensitivity of the results. The CNE is a wide-band emitter with 50Ω source impedance, hence matched to the LISN's used and having a well defined characteristic noise spectrum into a matched load (figure 2).

Test Harnesses

Test harnesses were constructed on 50mm plinths to provide a rigid and repeatable harness configuration and rapid set-up time for testing (figure 1). The harnesses have BNC connectors at either end for the main signal wire and ground. The ground return is provided either by a copper braid to the test ground plane for a chassis return configuration, at the CNE end of the test set-up, or via a wired ground 1cm from the signal wire.

Tests were conducted on 0.2m and 1.5m length harnesses since these are the standard harness lengths for automotive conducted and radiated emissions respectively [3,4].



Figure 1: Test Harnesses

Conducted Emissions Testing

Conducted emissions tests were performed in accordance with the set-up and methods of CISPR-25 [1,4]. Tests were conducted over the range 150kHz to 108MHz, with a resolution bandwidth (RBW) of 9kHz up to 30MHz and 120kHz above 30MHz.

Radiated Emissions Testing

Radiated emission testing was performed in an absorber lined screened room (ALSE) following the European automotive EMC directive 95/54/EC [2,3], this is similar to CISPR-25 set-up for radiated emissions testing. The emission results from both horizontal and vertical polarisation were measured and the maximum from either polarisation at each test frequency is used for the final result.

RESULTS

The absolute measured spectra are shown in appendix A, however, the purpose of this paper is to discover if there is a benefit to the emissions performance of the different current return methods. The majority of the discussion for the results shown in the text will be on the difference in the emissions measured; the wired return emissions level subtracted from the chassis return emission level for each measurement frequency on each harness. Consequently a positive measurement occurs where the chassis return emission is higher than the wired return result.

CNE Output

The output from the CNE is not truly flat, but has a characteristic shape easily identifiable in the measured plots. The CNE output (figure 1) does show a discrepancy for the conducted emissions result from 30MHz to 108MHz, this is primarily due to discrepancies in load matching from the LISN to the harness at the higher frequencies; from 30MHz to 108MHz (the end of the harness is connected via a 15cm cabled plug-to-BNC connector).

The output for the radiated emissions range was measured directly from the CNE without a LISN (30MHz to 1GHz). This shows a characteristic drop in the signal strength by approximately 10dB at 600MHz compared to the signal at 100MHz and below. The signal also has a noticeable peak just above 900MHz.

These idiosyncrasies of the CNE output itself are unimportant as the focus of the study is the

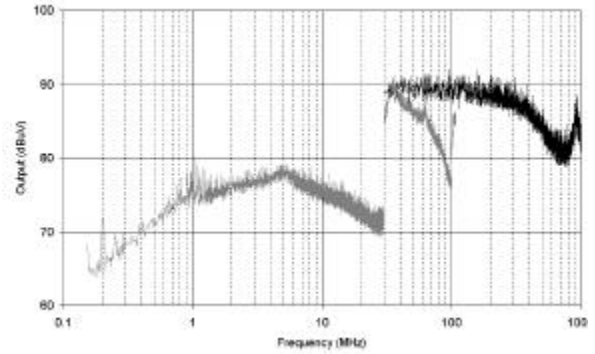


Figure 2: CNE Conducted Output into 500

difference between the two ground return methods. The CNE output was determined to be constant to within ± 2 dB at any given frequency within the measurement range using a peak detector.

Conducted Emissions

At frequencies below 1MHz there appears to be no discernable difference in the conducted emissions results between the two return configurations. Above 1MHz conducted emission levels appear to be lower from the wired ground than the chassis ground configuration at frequencies up to 10MHz, regardless of harness length. This low frequency behaviour is to be predicted as the impedance of the wired scheme is expected to be almost twice that of the chassis scheme, hence the harness is effectively acting as a filter below 10MHz. Below 1MHz the impedance difference is too small to be significant. This is clearly also true of longer harness lengths as shown in the data in appendix A, where the 1.5m harness has lower conducted emissions than the 0.2m harness at frequencies below 10MHz for both current return configurations.

Above 10MHz the onset of resonance in the 1.5m harness occurs firstly in the wired configuration,

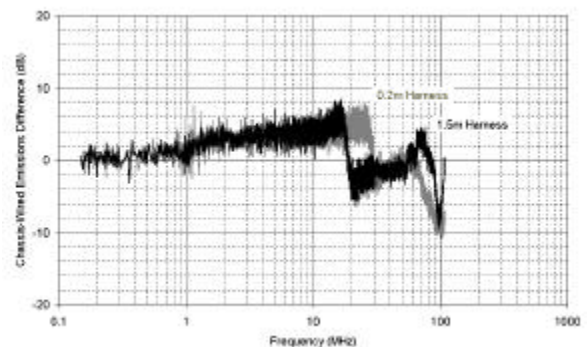


Figure 3: Conducted Emissions Difference

resulting in the chassis return having slightly lower emissions. Resonance on the 0.2m harness is a result of the interconnection from the harness BNC to the LISN and the results above 30MHz should not be observed under normal CISPR-25 testing. On-vehicle it is unlikely that any interconnection will be as short as 0.2m to the battery hence the resonance above 30MHz may represent the reality of connection and there does appear to be some small benefit due of a chassis ground providing delayed onset of cable resonance.

Radiated Emissions

Radiated emissions are less clear-cut, the overall emissions levels are generally lower for a wired ground return, but the resonances present in the emissions plot cloud the issue. The cause of lower radiated emissions with the wired ground scheme is believed to be a result of the smaller supply loop area. The loop area for each harness is its length multiplied by 1cm for the wired scheme and 5cm for the chassis ground arrangement, hence the chassis ground has five times the loop area of the wired ground configuration.

The loop area effect is not as easily observed in the difference between the two harness lengths, where emissions from the 1.5m harness exhibits more resonance peaks than the 0.2m harness (appendix A). The shorter harness still exhibits resonance effects above 100MHz in the radiated emissions plot, but having fewer peaks and troughs gives the overall impressions of a higher general radiated emissions level.

DISCUSSION

There is no overall “winner” exhibited here, it was the authors’ hope that it could be stated that chassis return is better due to lower impedance, or wired return is better due to smaller loop area. The truth is that the resonances at higher

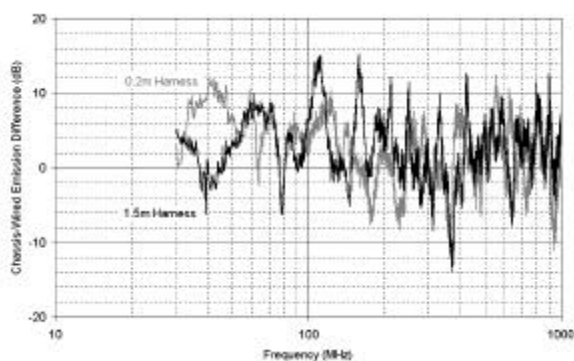


Figure 4: Radiated Emissions Difference

frequencies make a clear-cut answer impossible to give. On-vehicle the situation is likely to be even more confused as harness lengths are not only different from the test harnesses used for EMC test, but the harness will have different lengths to different ESA's, many interconnected again with different harness lengths.

The results suggest that longer harnesses do give more rejection of conducted emissions and that the wired configuration is slightly better than the chassis return. However the benefit is over a relatively short frequency range (1MHz-10MHz) Below 1MHz the higher impedance of the wired scheme is not significant enough to provide a tangible benefit. Above 10MHz the onset of cable resonance reduces the higher impedance benefit and if an ESA happened to have a component that could resonate with the cable there could be significant EMC problems.

If testing to CISPR-25 for conducted emissions the resonances in the cable should not be present (0.2m harness). Consequently there is an argument to suggest that a wired ground scheme will produce lower measured emissions than a chassis grounded scheme. The reduction could be as high as 6dB and may extend up to the 108MHz measurement limit of CIPR-25. This benefit will only be realised during test and is unlikely to be observed on-vehicle.

CONCLUSION

Overall it would appear that there are some EMC benefits to using a wired grounded scheme for automotive ESA's. However, the reduced overall levels have to be weighed against the earlier onset of resonance. The potential easier installation of wired compared to chassis grounding schemes is also a benefit and will probably result in a more consistent EMC performance over the life of the vehicle.

Ultimately, as with most automotive ESA performance targets, cost will be the dominating factor. If a product is already in a metalised and grounded case then chassis grounding will be the preferred return current scheme. If an insulated case is used then wired grounding would be implemented.

ACKNOWLEDGEMENTS

C.C. Leung of 3C Test Ltd performed the test set-up and measurements reported in this paper. Murray Edington of Ricardo Consulting Engineers provided a sounding board for the discussion and conclusions.

REFERENCES

[1] M. O'Hara and J. Colebrooke, "Automotive EMC Test Harnesses: Standard Lengths and their Effect on Conducted Emissions", *2003 IEEE International Symposium on Electromagnetic Compatibility (EMC)*, Istanbul, 11-16 May 2003.

[2] M. O'Hara and J. Colebrooke, "Automotive EMC Test Harnesses: Standard Lengths and their Effect on Radiated Emissions", *York EMC 2003*, York, 1 July 2003.

[3] Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers

[4] CISPR-25: 2002 - Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles.

Biographical Notes



Martin O'Hara is the author of "EMC at Component and PCB Level", obtained a BSc in Applied Physics from Durham University and an MSc in Instrumentation from Manchester Polytechnic. Currently working for Trafficmaster UK designing in-vehicle telematic hardware platforms for vehicle tracking and navigation applications.

APPENDIX A: MEASURED EMISSIONS

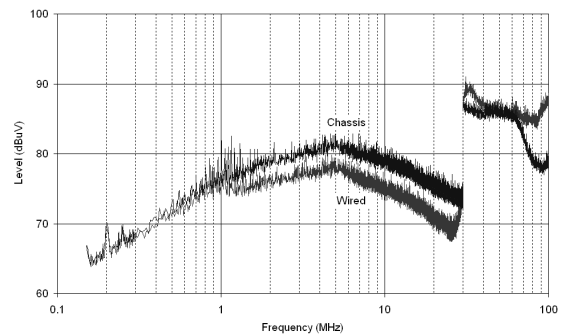


Figure 5: 0.2m Harness Conducted Emissions

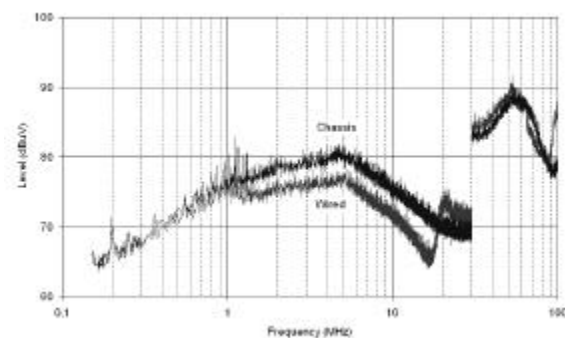


Figure 6: 1.5m Harness Conducted Emissions

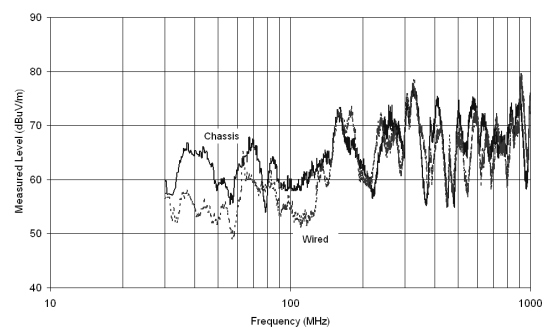


Figure 7: 0.2m Harness Radiated Emissions

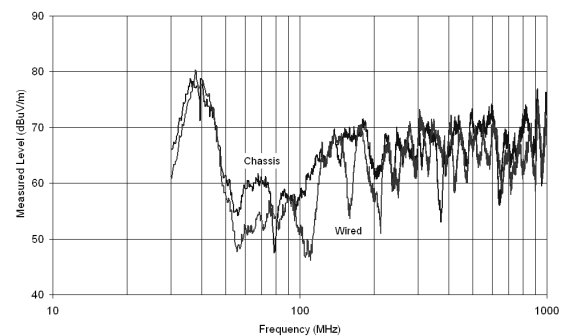


Figure 8: 1.5m Harness Radiated Emissions