International Amateur Radio Union Region 1

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Subject	**Electric Cars and Chargers**		
Society	NRRL	**Country**	Norway
Committee:	**EMC**	**Paper number:**	**C7-01 v2**
Author:			

Background

IARU has caught interest in electrical vehicles and their charging devices as these may have large potential of creating EMI.
In Norway the relative number of these types of cars are one of the highest within EU, NRRL was therefore asked to look into the practical EMI-threat this may impose for the Radio Amateur service.

Introduction

At an early stage we divided the investigation into the following main areas:

1. Public chargers
2. Private (home-) chargers
3. The car while driving

Most public chargers are dual mode i.e. capable of supplying AC and/or DC charging. AC is used for cars with internal or external chargers for 230/400 Volt.
DC charging seems to be the most popular for public chargers since they can deliver very high energy, i.e. more energy per minute.
In addition hi-power chargers, often called 'turbo'-chargers or 'super-chargers' deliver >300kW DC are available.

For home usage there are two sub groups:

ordinary 'Suko' plug 230V / 16A
fixed wall mounted 230V / 3x32A
Both types can handle one car at the time.

An electrical vehicle has the potential of creating EMI when a battery, >200 V, is delivering 500 kW into 2 of 4 motors controlled by various sorts of electronics. In the opposite situation the motors are used as regenerative brakes to charge the batteries in downhill situations, or when releasing the throttle.

Requirements to EL-vehicles

The EMC requirements for electrical vehicles are set down in 95/54/EC; CISPR 25, ed.4. / ISO 11452

Investigations

Due to practical reasons it has not been possible to perform EMC/EMI measurements using a LISN as specified in the International standards .
We have therefor implemented a practical evaluation test via a wide-band antenna and a receiver and a spectrum analyzer measuring the real-life situation. Further information on the setup and the equipment is found here: file: Set-up.ppt (attached)

The focus has been on frequencies between 1.8MHz and 50MHz. The 134kHz and 144MHz band have also been on the agenda, but with less focus.

One of the other limiting factors has been the physical locations of the chargers, they are mostly found in urban areas, typically in shopping malls and close to railway stations (P&R). The challenge with these places are the background noise is often high, and in some situations too high to make useful measurements.

Conclusions

As we have feared the charging of hi-power batteries with a switch-mode based system creates EMI, to which extent are dependent on various factors:

- Standard home chargers running on 230V AC, up to 13A, are creating EMI. In some situations the entire spectrum up to 21 MHz is blocked (S9 or more).
- Hi-power chargers deliver DC in the order of 60 – 140A, some of these are found to be the worst from a EMI perspective. In this project only public hi-power chargers has been visited.
- In both cases there are significant differences between the different car manufacturers, clearly indicating that the electronics inside the car contributes significantly to the EMI.
- So far no solid observation of EMI from driving cars along the road. In an electrical car using the car-radio to listen on LW or MW is impossible, this is quite obvious, and regarded as outside the scope for this investigation.
- Chargers from different manufacturers generate different EMI-levels.
- Vehicles from different manufacturers generate different EMI-levels.
- Low HF (1.8 – 10MHz) is most vulnerable.

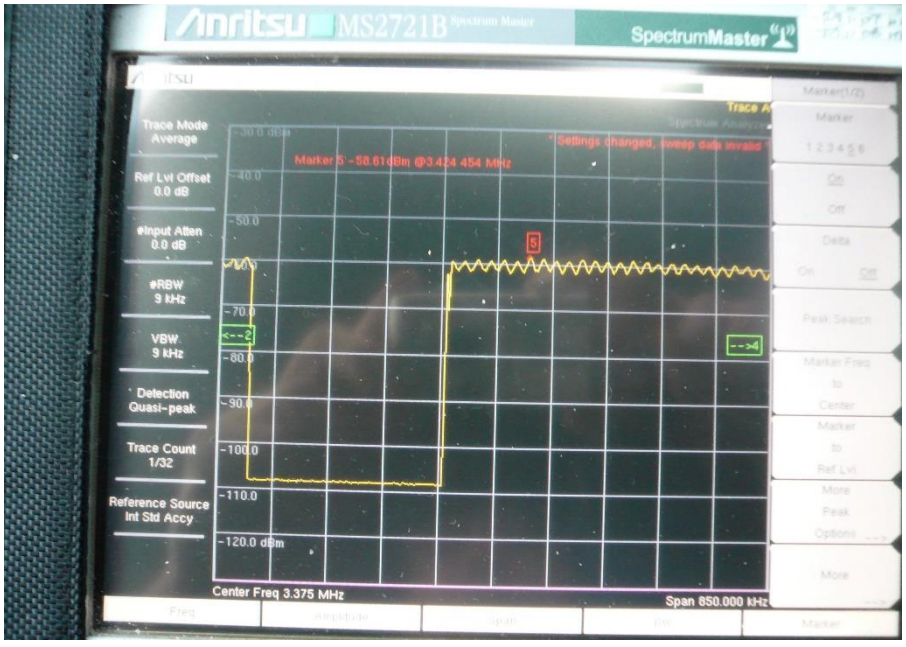
In all observed cases it seems that the switching frequency is varied (by interleaving) in an attempt to avoid power-peaks on specific frequencies, as a result there are no 'interference free' frequencies.

More detailed results

Measured EMI (dBm)(1)								
		Band						
Car type:	**Charging info**	**1.8 MHz**	**3.5 MHz**	**7 MHz**	**5 MHz**	**10 MHz**	**14 MHz**	**21 MHz**
Nissan LEAF	AC							
Renault ZOE	AC		-82					-97
Tesla Model S	DC 100A		-79 / -55	-80		-82/ -92	-88/ -100	-93
BMW eDrive	DC 108A		-78	-82		-73		
KIA SOUL	DC 59A	-66	-62		-72(2)	-70(2)	-92	

(1) Detector: QP; BW: 9kHz
(2) RMS, BW: 10 kHz

On 144MHz no EMI is noted, however increased background noise in the 100 – 138 Mhz from the 'ENSO' chargers.



The picture show an example of EMI on 80-m band from a DC-charger delivering approx 60A.

The antenna was removed for some few secounds to show the background noise level; approx -108 dBm, compared to the EMI at approx -50 dBm.

Relevant background information:

[] http://www.stefan-peter-weber.de/publikationen/pcim03.pdf