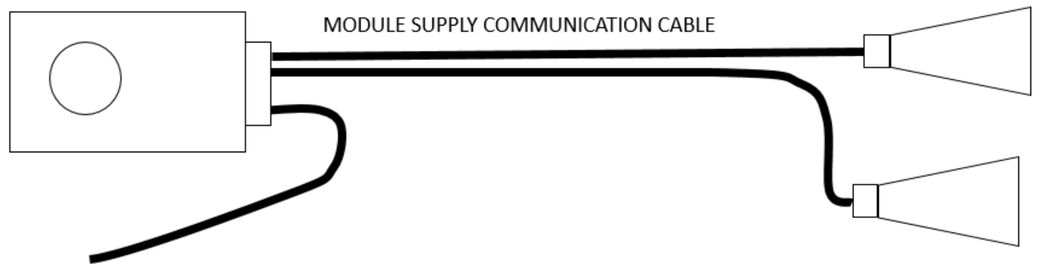
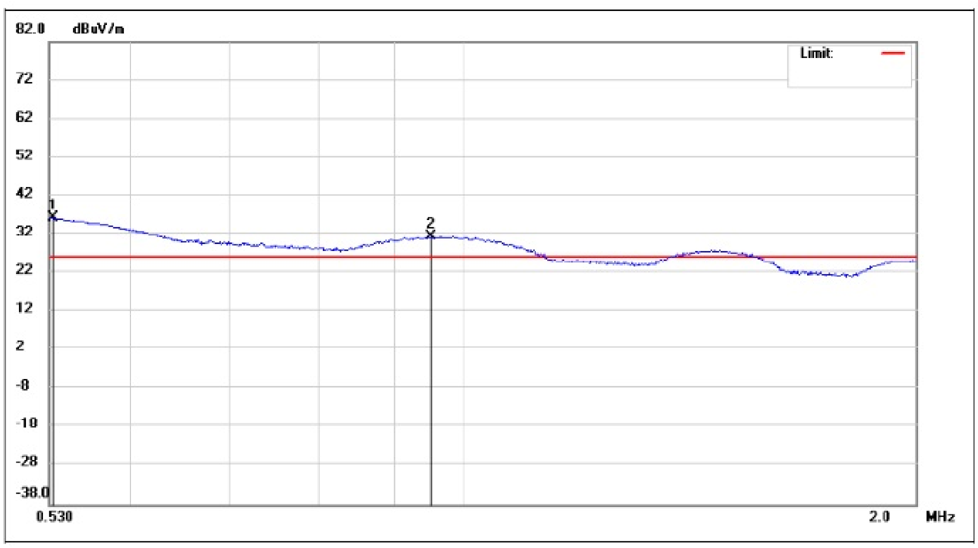
Radiated noise measurement example using Tekbox TEM Cells

1 Introduction

A customer asked us to solve a radiated noise issue of an ultrasonic parking radar device. The device failed CISPR 25, Class 4 narrow band radiated noise testing in the frequency range 530 kHz -2 MHz. The device consists of a controller with buzzer and two radar modules. Wiring consists of a supply cable to the controller and a communication/supply cable between controller and the two radar modules.



The customer supplied a screenshot of the failed test, measured in an anechoic chamber.



No.	Frequency	Reading	Factor	Result	Limit	Margin	Detector	P/F	Remark
	(MHz)	(dBuV)	(dB/m)	(dBuV/m)	(dBuV/m)	(dB)			
1	0.5335	35.91	0.30	36.21	26.00	10.21	peak	F	
2	0.9507	31.36	0.15	31.51	26.00	5.51	peak	F	

The measured conducted emission spectrum exceeds the limit for CISPR 25 class 4 in the range 530 kHz to approximately 1.1 MHz. Furthermore the customer provided the information, that the test also failed with the module cable disconnected.

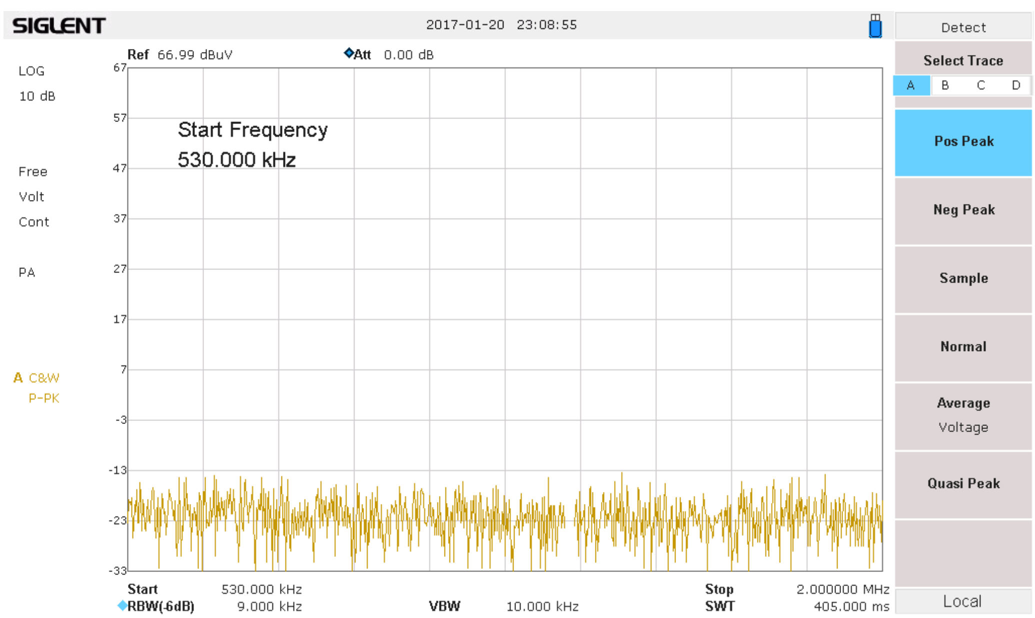
2 Approach

Looking at the spectrum gives a first clue. Given the low frequency range at which the emissions of the device exceeded the limits points points to a relatively low frequency digital signal. The relatively wide band noise, the absence of discrete spectral lines points to the emissions from the microcontroller itself or to serial interface between controller and radar modules.
As the customer mentioned, that the device also failed with the cable to the module disconnected, the initial suspicion fell at the microcontroller.

3 Test set up and measurements

EMC sniffer probes and TEM cells in combination with a spectrum analyser are the basic tools to identify the source of radiated emission issues.
As the sensitivity of H- and E-field probes in the kHz range is not very high, a Tekbox TBTC3 TEM cell was used for testing straight away. The involved spectrum analyser was a Siglent SSA3021X.
A challenge measuring CISPR25 class 4 or class 5 radiated or conducted noise are the relatively low limits of the standard with respect to the noise floor of low cost spectrum analyzers.
As for the open TEM-Cell, measurements at low levels in the kHz and low MHz range may be handicapped by ambient noise from nearby switched mode power supplies and AM broadcast signals.

Turning on the spectrum analyser and setting:
Span 530 kHz – 2 MHz; BW 9 kHz; Attenuator 0 dB; Preamplifier On; Average Voltage; Positive Peak Detector shows the spectrum below:



The displayed noise floor with this settings is approximately at -20dBµV which is impressive for a Spectrum Analyzer of this class. However it needs to be considered that the the frequency range of interest is crowded with AM broadcast signals which are likely to be picked up.

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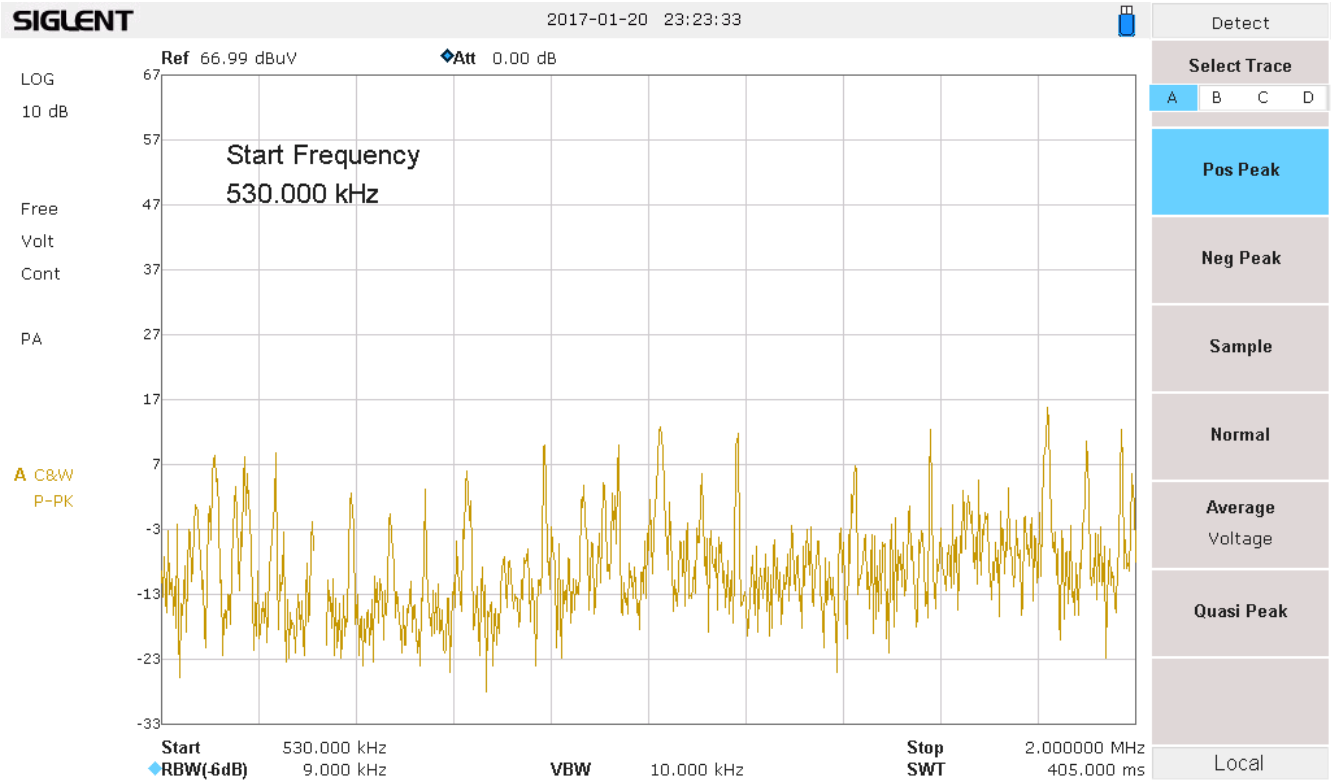
Connecting the empty TEM cell shows following spectrum:



As expected, the frequency range is crowded with broadcast signals. It next needs to be figured out, if the emissions of the DUT are above or in between with respect to amplitude.

DUT setup

Next, the DUT including cables and radar modules is placed inside the TEM cell and powered ON:

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The Spectrum Analyzer trace is set to Max Hold:

The “hills” visible in the measured spectrum nicely correlate with the plot of the measurement in the anechoic chamber, despite the presence of some peaks from AM broadcast signals. The amplitude measured in the TEM cell is approximately 20 dBµV lower compared to the amplitude measured in the anechoic chamber.

Next the cable is removed, as according to the customer, it also failed with the cable removed
For simplicity sake, the cable remains physically connected, but is moved to the side with respect to the septum of the TEM cell.

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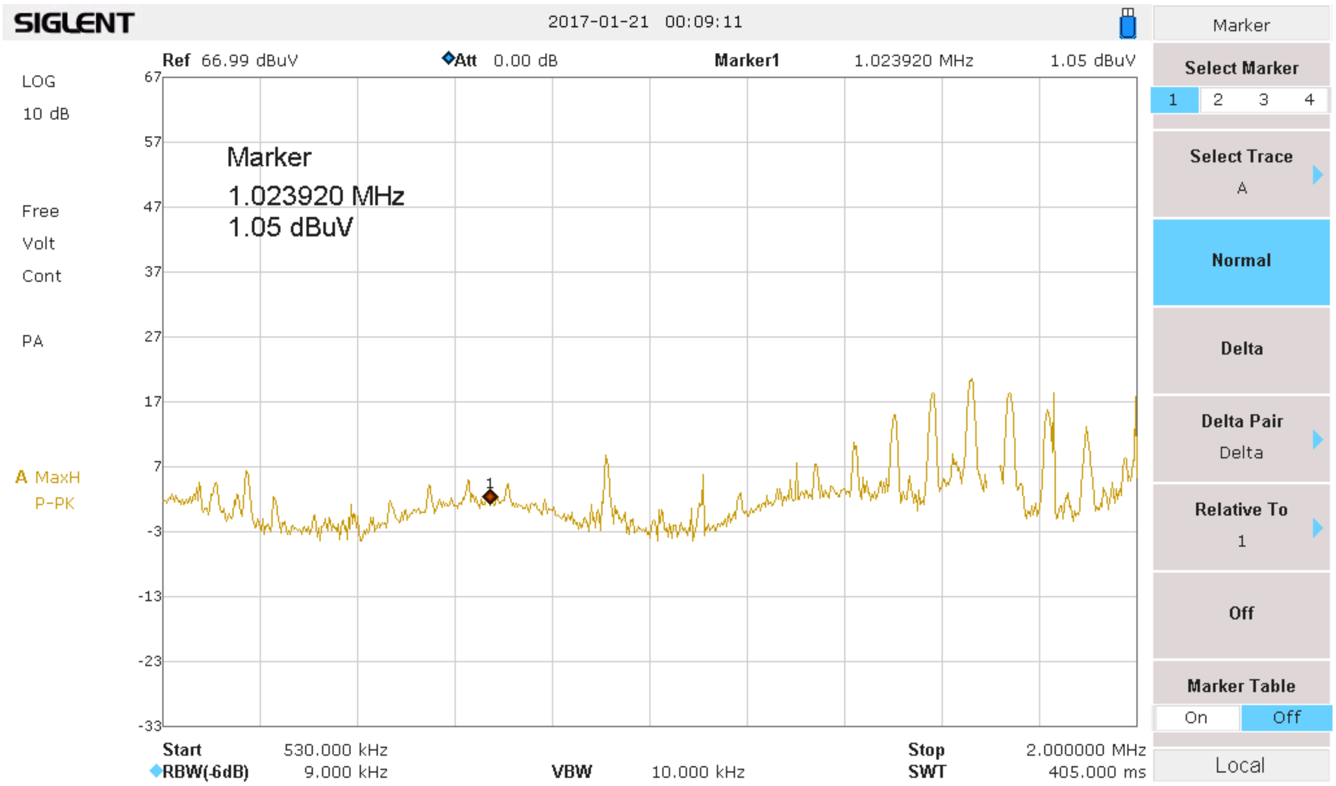
Surprisingly, shifting the cable significantly reduces the radiated noise of the DUT:



“Removing” the cable reduces the radiated noise at abpproximately 11 dBµV. Checking back with the customer turned out, that in fact not the cable was removed, but the two radar sensors were disconnected. This also explains why the relative amplitude of the spectrum “hills” are a bit different compared to the TEM cell measurement. The cable was set up straight in the anechoic chamber, whereas in the TEM cell it is coiled.

4 Conclusion

Removing the cable significantly reduced the radiated noise of the DUT. Though the customer removed the radar modules, he still failed the test. In fact, even in the absence of the modules, the controller continuously tries to communicate over the serial cable – without any timeout. Consequently it is highly probable, that the serial communication interface between the controller and radar modules is the culprit. In order to solve the issue it is necessary to apply some filtering to the interface.
As ferrites are not very effective at low frequencies, it was decided to add resistors in series with the cable. This seemed to be an especially practical approach, as there were already 0 Ohm series resistors assembled on the PCB. Replacing the 0 Ohm series resistors with 1K reduced the radiated noise level at approximately 12 dBµV. However it turned out that the serial interface did not reliably operate over the specified supply voltage range any more. Finally it was also necessary to adjust a few other resistors in the transistorized serial interface circuit in order to solve the radiated issue and keep the performance of the serial interface within specs. A few modifications and measurements later, the result looks as below:

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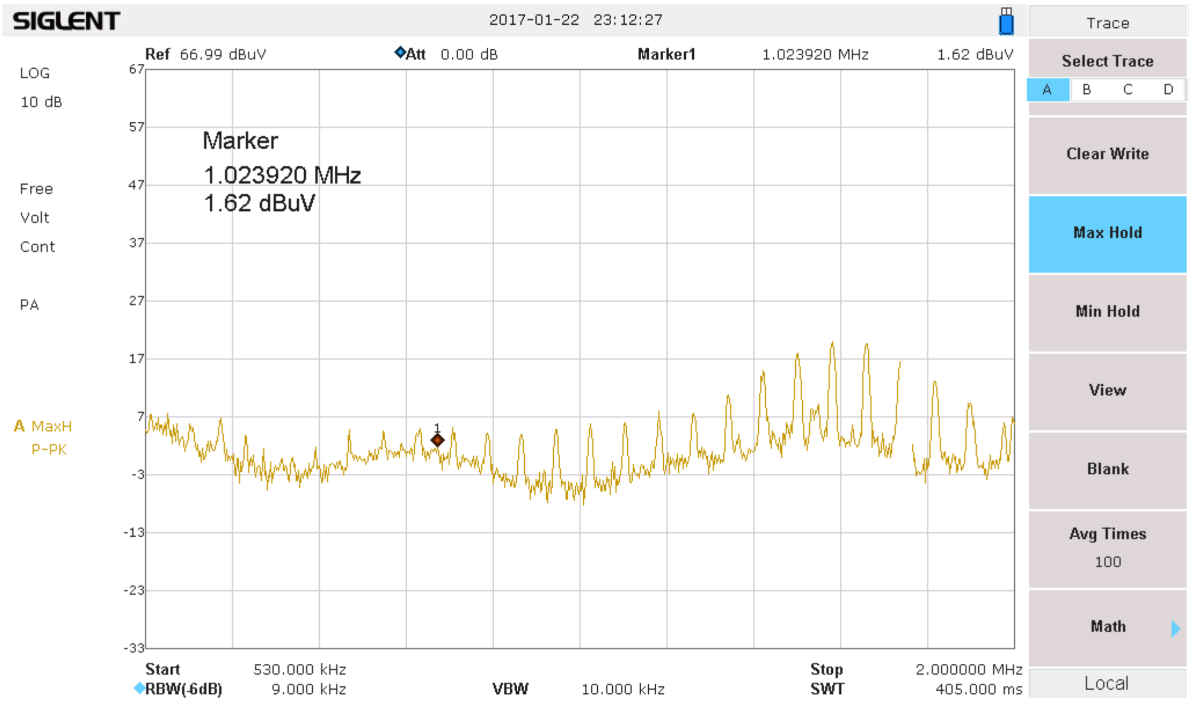
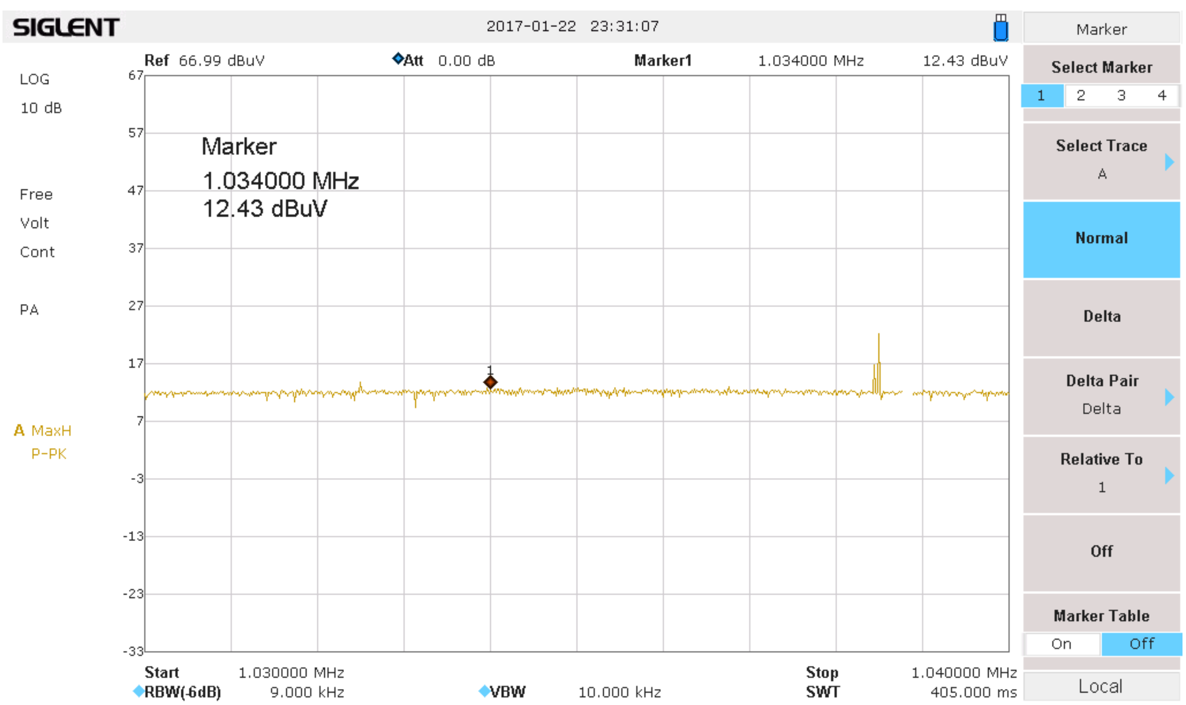


In order to get a clearer picture, the span of the Spectrum Analyzer was reduced and set in between two adjacent broadcast channels.
Below a “zoomed” screen shot before the modification:



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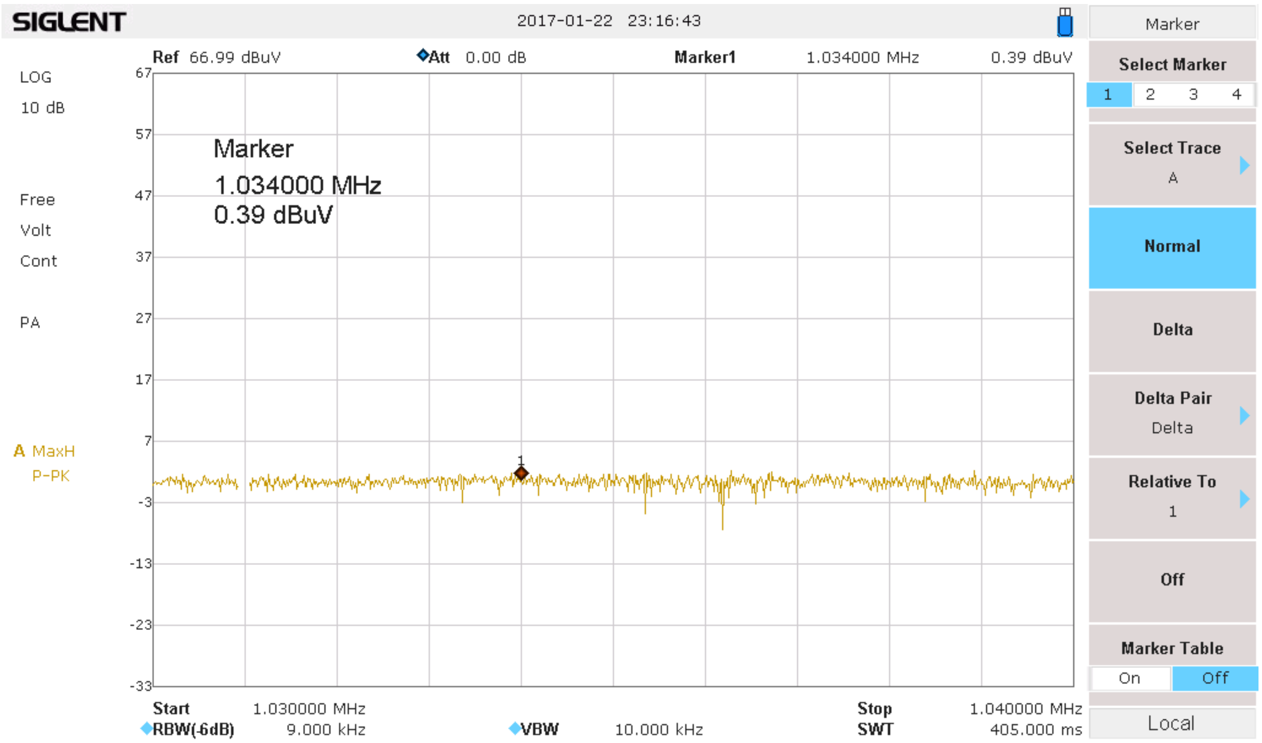
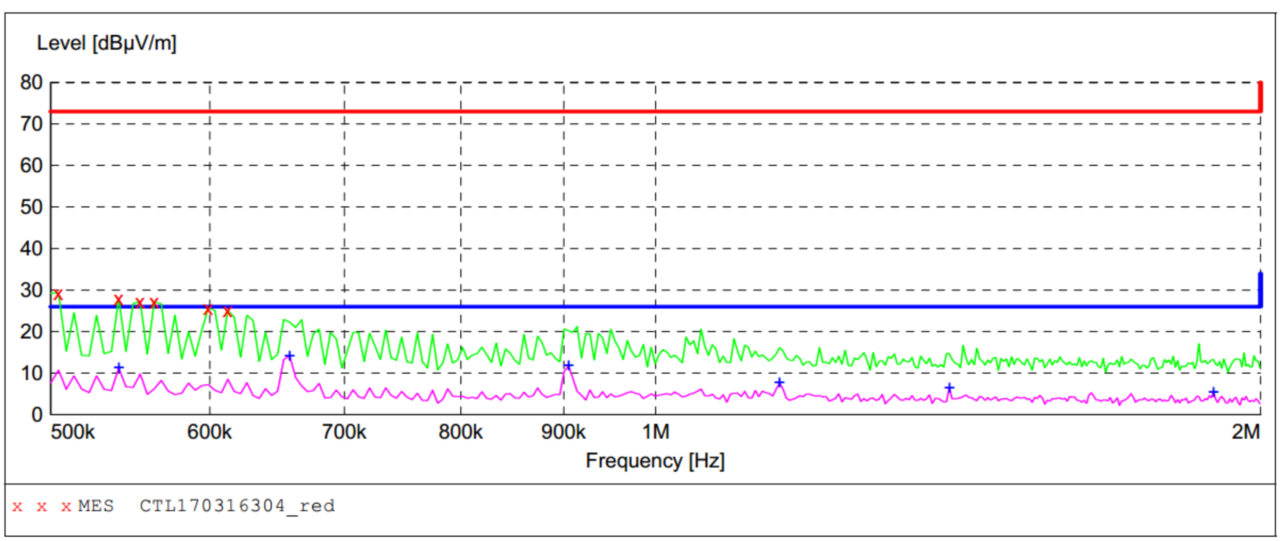
Next a zoomed screenshot after the modification:



The modification gave a 12 dBµV reduction of the radiated emissions level at the investigated frequency.

Below the final measurement plot from the test house, after modification:
The device passed the radiated noise test in the range 500kHz to 2MHz and furthermore the remaining frequency range up to 2GHz.



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5 Summary

An affordable set up consisting of a Siglent Spectrum Analyzer SSA 3021X and a Tekbox TEM-cell was successfully used to measure and reduce radiated emission issues. The emissions had a relatively broad spectrum and no sharp peaks; The set up worked very well, despite low amplitudes and a frequency range with much ambient spectrum from broadcast stations.
The setup of the DUT inside the TEM cell gives a very repeatable result without the requirement to accurately re-position the DUT after every modification. Whereas EMC probes are ideal to exactly locate/identify the source of emissions on a PCB, the strength of the TEM cell is its capability to exactly measure the relative improvement with respect to the emission amplitude after modifications in order to achieve compliance. It is also very practical to measure complete emissions of a product consisting of several separate devices and the interconnecting cables.
The test setup requires only little space and can amortize nearly immediately. Improving the parking radar required several iterations in order to find an ideal solution which both satisfied EMC and functional requirements. If after every iteration, a re-measurement had to be done in the anechoic chamber, costs most likely had exceeded those for purchasing the Spectrum Analyzer and TEM cell.

6 History

Version	Date	Author	Changes
V1.0	23.01.2017	Mayerhofer	Creation of the document

Table 1 – History