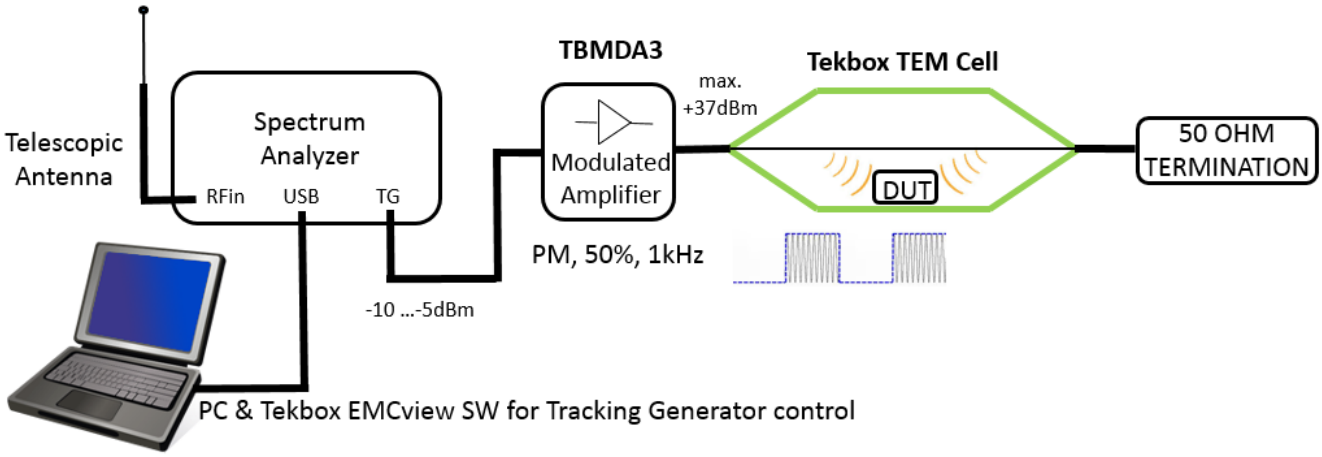
Immunity testing example using Tekbox TEM Cells

1 Introduction

A customer asked us to solve an immunity issue of a corner light. The device failed BCI testing in the test house at frequencies in the 300 MHz to 400 MHz range. The failure mode was flickering of the LEDs. An automotive BCI test requires a powerful wideband RF amplifier and a suitable current probe to inject RF into the supply line. As this test requires equipment which is not available in every design lab, Tekbox used a test set up which can trigger similar effects with simple pre-compliance equipment. Subsequently, the failure mode could be reproduced, the sensitive spot of the DUT could be localized and the immunity issue could be cured.

2 Test setup



Picture 1: block diagram of the test set up

In order to keep the list of required equipment as short as possible, the tracking generator of a spectrum analyser serves as a RF signal generator. When the spectrum analyser is set to zero span, the tracking generator outputs RF at a constant frequency. Changing the centre frequency of the spectrum analyser changes the TG output frequency accordingly. The output level of spectrum analyser tracking generators can typically be set in 1dB steps from -20 dBm to 0 dBm. Tekbox modulated wideband RF amplifiers are designed to deliver their full output power when fed with a tracking generator signal.
A PC running EMCview from Tekbox provides comfortable tracking generator control.
The TBMDA3 modulated power amplifier with its output power of up to 5W and its useable frequency range of 10 MHz to 1.2 GHz drives the TEM cell. In order to apply “brute force”, a TBTC0 TEM Cell is the weapon of choice. With its low septum height it can create fields up to 500V/m when driven by the TBMDA3.
A telescopic antenna was connected to the RF input of the spectrum analyser to have a means of visual feedback. As the TBTC0 is an open TEM cell, it radiates some RF, typically decreasing with a rate of 30dB per meter of distance. This is sufficient to be picked up by the antenna in order to display the envelope of the amplified and pulse modulated RF signal.

This set up basically tests radiated immunity. However in order to mimic the BCI test to a certain degree, besides the DUT, a portion of the supply cable was placed under the septum to radiate RF into the supply lines.

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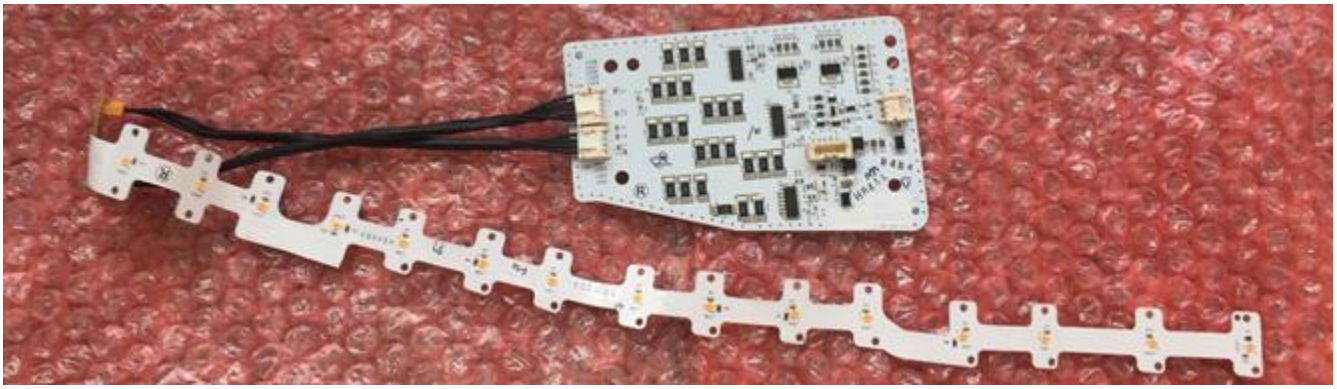
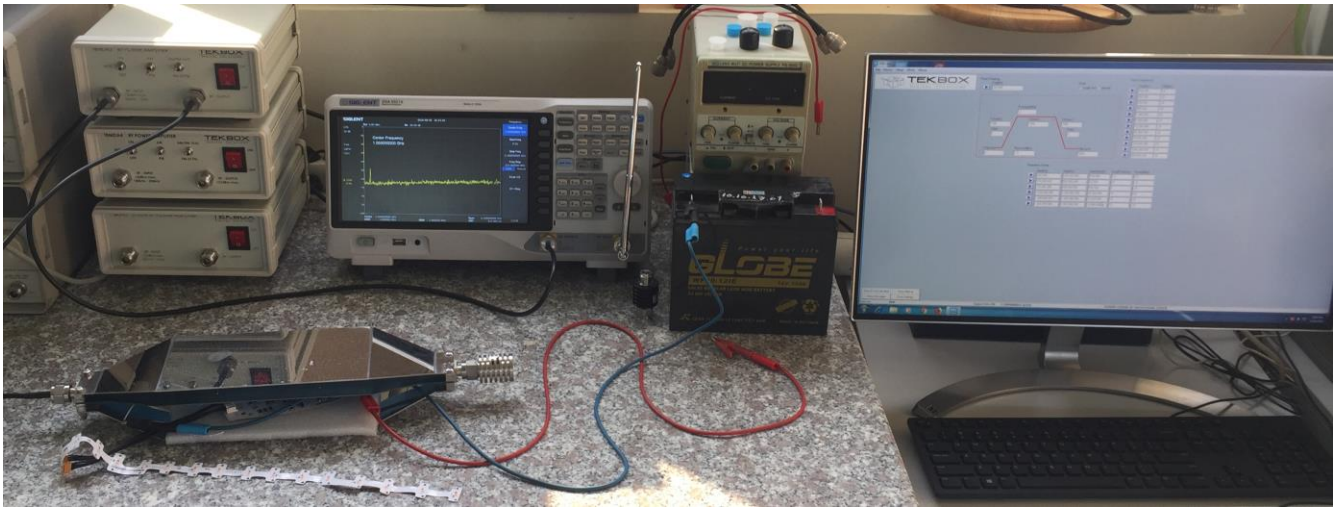


Picture 2: photo of the DUT

Picture 3: DUT inserted into the TBTC0 TEM cell



Picture 4: photo of the complete test set up

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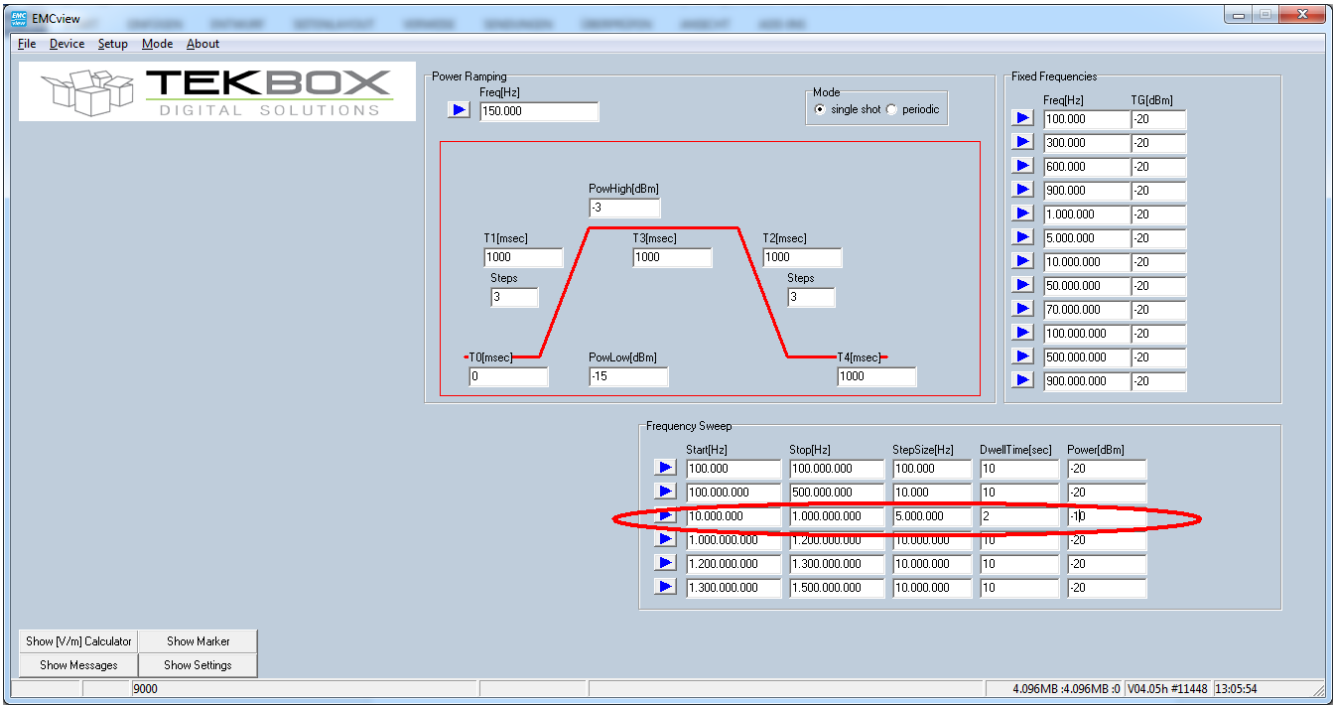
3 EMCview

EMCview currently supports tracking generator control of Rigol and Siglent spectrum analysers. The SW is regularly updated and support for additional spectrum analyser models will be added.
After starting EMCview, connection with the Siglent Spectrum analyser needs to be established first. This is done in the menu DEVICE, SA USB. Clicking the SEARCH button lists any connected devices. Selecting the Siglent SA and pressing CONNECT VISA establishes the connection.

EMCview offers modes for radiated and conducted EMC measurements, RF coverage measurements and tracking generator control. In order to enter the TG control mode, select menu MODE, GENERATOR.
In GENERATOR mode, lists of fixed frequencies and sweeps can be defined by the user.
As the DUT was reported to have an issue in the 300 MHz to 400 MHz region, a sweep from 10 MHz to 1 GHz, a dwell time of 2 seconds per frequency and a frequency step size of 5 MHz was entered. The TG amplitude was set to -10 dBm in order to get maximum output power from the TBMDA3 modulated amplifier.



Picture 5: set up of the sweep parameters

Finally, the DUT was powered and the sweep was started by pressing the PLAY (arrow) button.

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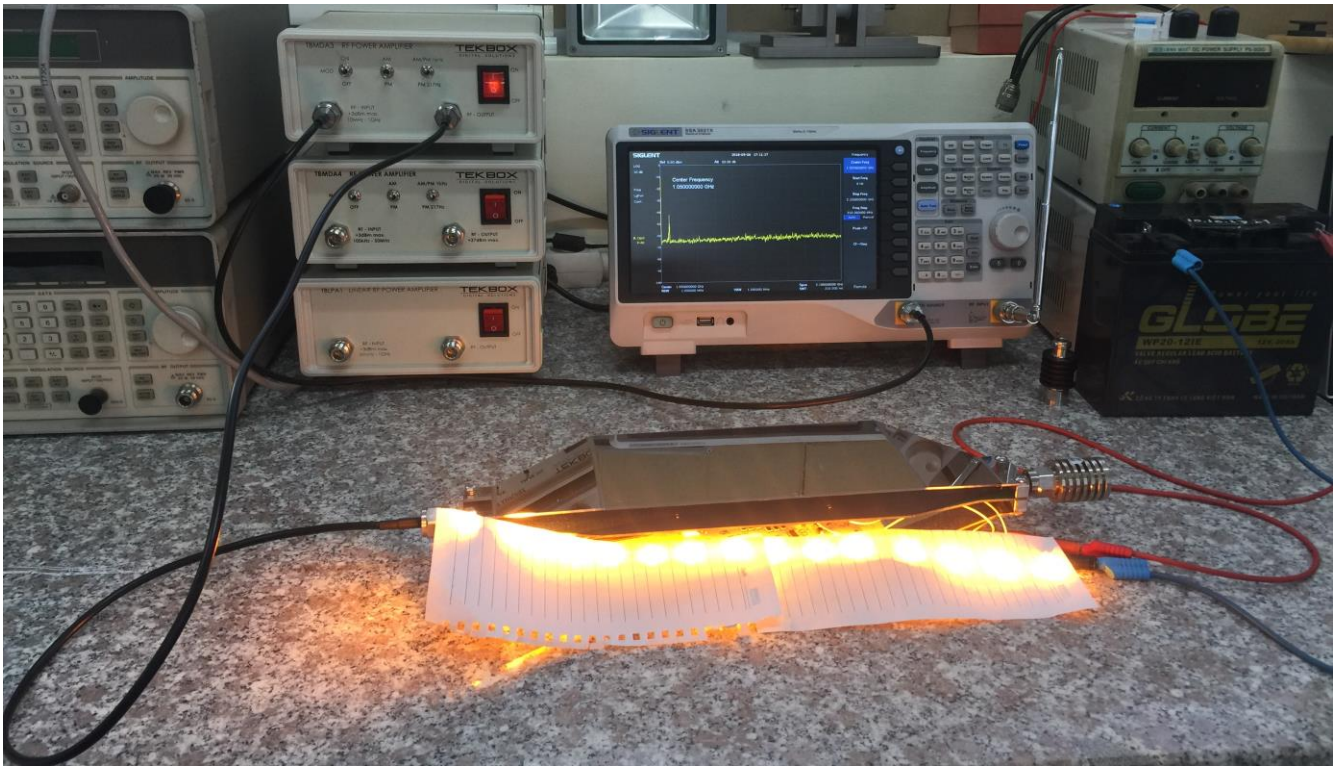
4 Frequency sweep

The frequency sweep starts immediately after pressing the PLAY button. The envelope of the signal can be monitored on the spectrum analyser. The amplitude of the envelope will change with frequency, due to the frequency characteristics of the telescopic antenna.

The sweep passed 300 MHz, with stable performance of the DUT. However, close to 800 MHz the LEDs started flickering and then went completely off, nearly all the way up to 1.2GHz.
The frequency difference with respect to the issue reported from the BCI test may be explained by the different supply cable length and consequently cable resonance during BCI test and the TEM cell test.



Picture 6: powered DUT, immediately before starting the sweep

Click the link below in order to see a video of the DUT in failure mode. The sequence covers the sweep in the 800 MHz region:

https://www.youtube.com/watch?v=APnuj_J1I7k&feature=youtu.be

The next video shows the DUT failure after EMCview TG control was changed to a fixed frequency and the TG power being turned on and off:

https://www.youtube.com/watch?v=9Mm6ZAb1R2g&feature=youtu.be

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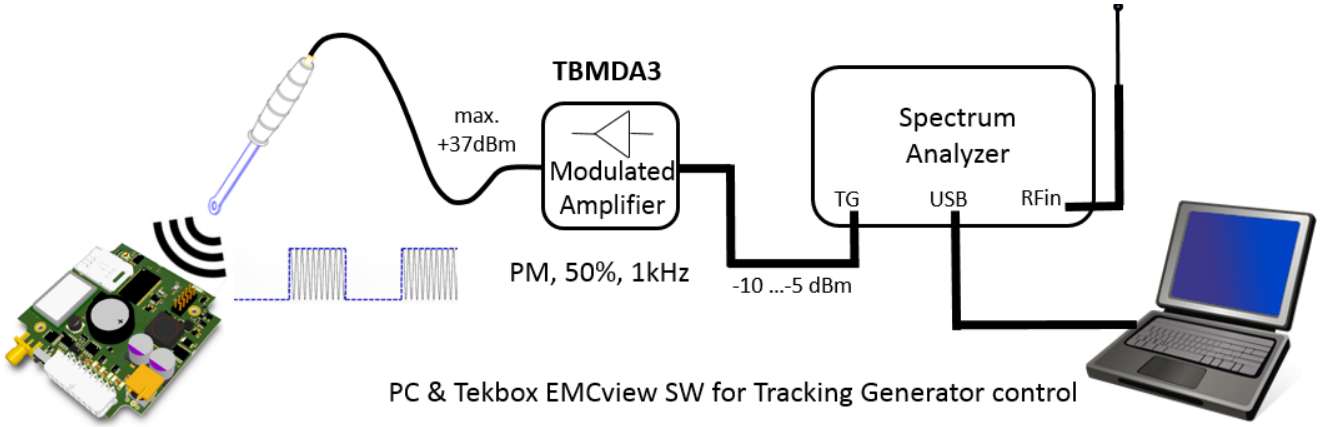
5 Identification of the sensitive spot

Now that the immunity issue could be reproduced, the setup was modified in order to search for the root cause.



Picture 7: immunity test set up using near field probes to inject RF

The tracking generator was set to a fixed output frequency of 850 MHz, -10 dBm using EMCview.
The DUT was removed from the TEM cell and the output of the TBMDA3 modulated wideband power amplifier was connected to a Tekbox near field probe. The probe was then moved across the components and traces of the DUT PCBA, until the sensitive spot could be located.

Click the link below in order to see a video of this procedure.

https://www.youtube.com/watch?v=h7vOVASKtPc&feature=youtu.be

6 Analysis and fix

The LED driver consists of three independent linear constant current regulator ICs, each driving a string of 5 LEDs.
The test with the near field probe shows that whenever coming close to a few components next to the regulator IC of any of the three identical sections, always all 15 LEDs turn off.
This was surprising, as the near field probe only radiates into a small area of the PCBA. Initially it was expected that only single strings will be affected. Consequently, the entry point must be a trace, which is shared by all three ICs.
A quick look at the schematic revealed that all three current regulators only had the Enable pins tied together. The Enable pins are interconnected via relatively long traces to a pull up resistor. This would also explain an entry point for the RF via the positive supply line during the BCI test.

Next, a 1 nF decoupling capacitor was soldered to the Enable pin of each IC. The TEM cell test was repeated with the modified DUT and the immunity issue was cured.
Subsequently the customer modified the DUT accordingly and successfully passed the BCI test.

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7 History

Version	Date	Author	Changes
V1.0	27.09.2018	Mayerhofer	Creation of the document