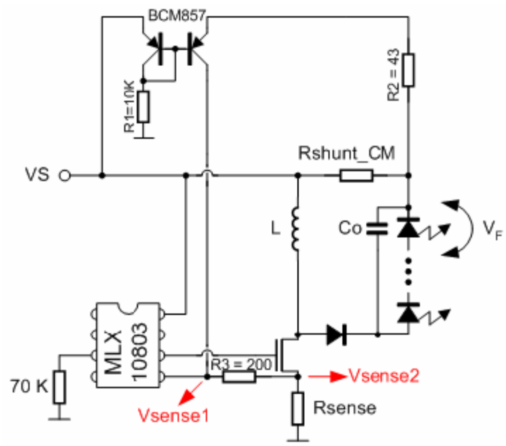
1 Scope

The scope of this application note is to show EMC measurement results of a 15W implementation using 6 white LEDs at 700mA on the Buck-Boost reference design board EVB10803_5.

2 Table of contents

3 Component calculation

As explained in the Buck-Boost reference design application note, the Buck-Boost calculation tool calculates the values to set the operating point at critical conduction. The supply variations are compensated using a current mirror:



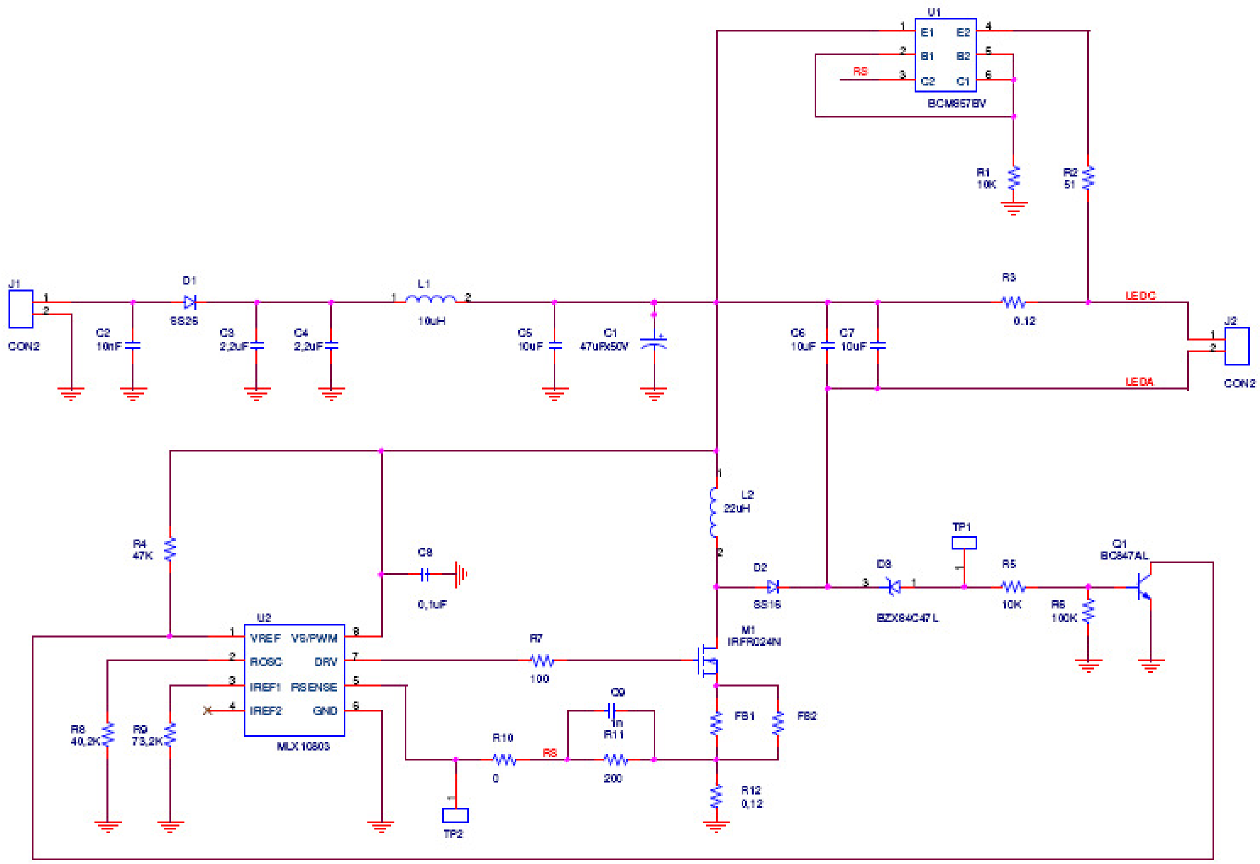
INPUT DATA	
Min. supply, VS	9
Nom. supply, VS	13
Max. supply, VS	16
LED Forward Voltage, VF	3.5
Number of LEDs in series	6
Average current: LED , mA	700
Tmonoflop, uS	2.5
L (the Coil), uH	22

OUTPUT DATA	
I coil_peak (VSmin) , A	4.08
I coil_peak (VSnom) , A	3.28
I coil_peak (VSmax) , A	2.96
Rosc, Kohm	40
Rsense, Ohm	0.09
Rshunt_CM, Ohm	0.11
Min. switching frequency, kHz	80
Nom. switching frequency, kHz	124
Max. switching frequency, kHz	152
Avg. current FET (Vsmin), A	1.63
Nom Output Capacitor Co, uF	10.2

From this calculation sheet the 22uH switching coil has to be able to switch a peak current at 13V of at least 3.3A. For this application a Cooper Bussmann DR125-220 can be used:

Part Number	Rated Inductance (µH)	OCL[1] +/-20% (µH)	I_{rms}[2] Amps	I_{sat}[3] Amps Peak	DCR[4] (Ω) Typ.	Volt-µSec[5] Typ.
DR125-3R3-R	3.30	3.084	9.26	12.7	0.0063	8.23
DR125-4R7-R	4.70	5.274	7.18	9.71	0.0105	10.8
DR125-6R8-R	6.80	6.588	6.64	8.68	0.0123	12.0
DR125-8R2-R	8.20	8.048	5.54	7.86	0.0176	13.3
DR125-100-R	10.0	9.654	5.35	7.17	0.0189	14.6
DR125-150-R	15.0	15.35	4.27	5.69	0.0298	18.4
DR125-180-R	18.0	17.70	3.81	5.32	0.0377	19.6
DR125-220-R	22.0	22.36	3.70	4.71	0.0396	22.2
DR125-330-R	33.0	33.74	3.28	3.84	0.0505	27.2
DR125-470-R	47.0	47.47	2.71	3.24	0.0740	32.3

4 Application schematic

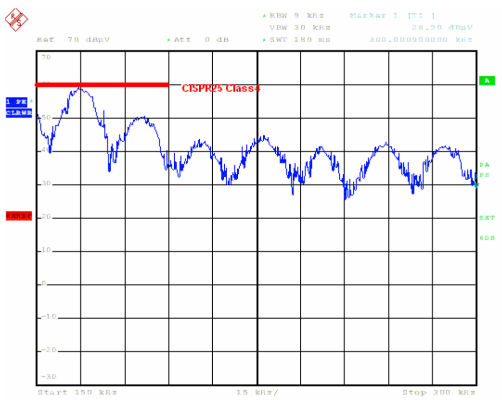


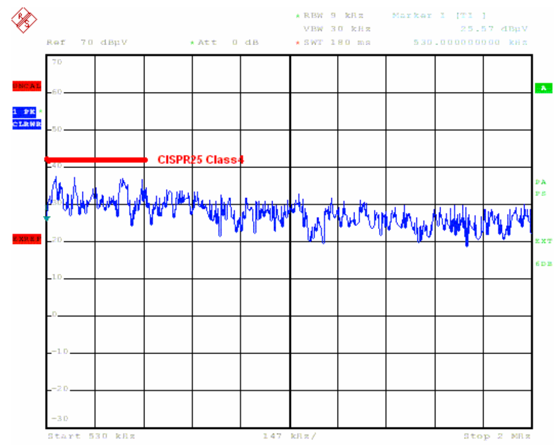
15W Buck-Boost schematic

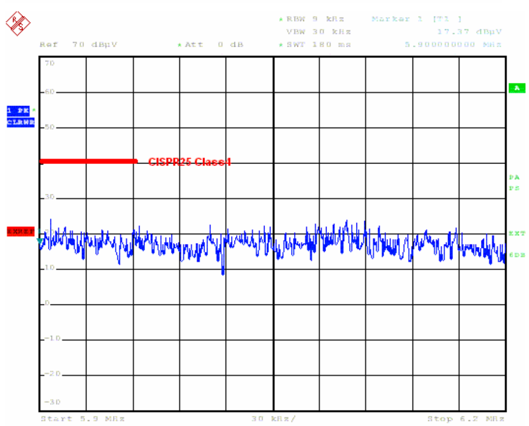
The reference design board MLX10803_5 has been used with the shown bill of materials, yielding the EMC results at the end of the document. It differs on some points from the reference design:

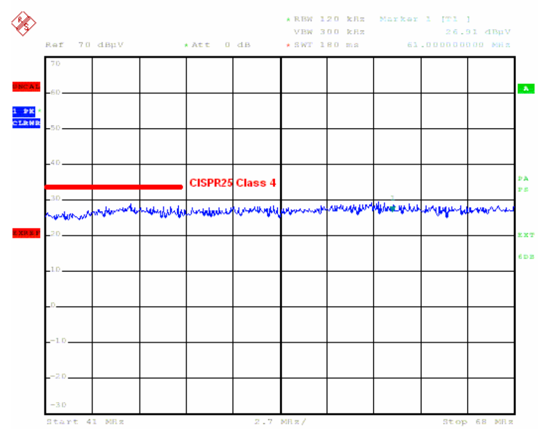
- Transistor Q1 serves to realize open circuit protection by pulling VREF down. This is an alternative circuit to shorting TP1 and TP2, and use D3 as feed forward on R10 as is described in the Buck-Boost reference design application note.
- Cap C9 can be removed as it has no influence.
- The 20uF capacitance (C6+C7) over the LEDs limit the ripple of the LED current to 10% peak to peak (+/-5%) at VBAT=13V.
- Elco C1 = 47uF serves as damping capacitor for the LC resonance of the input filter.

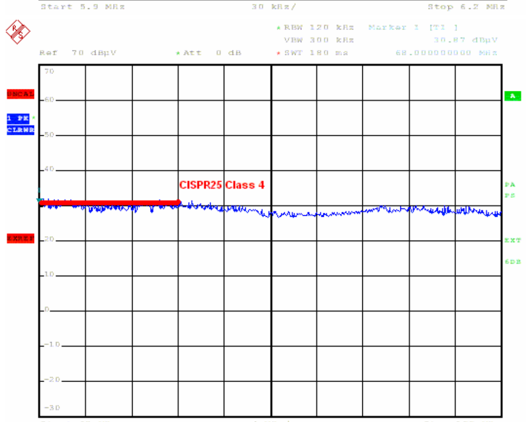
5 CE measurement results according to CISPR25 – Peak detection











The Low Frequency band image [150, 300] kHz clearly shows the different switching frequencies spaced at 120 kHz/8 ~ 15 kHz due to the randomisation. The shown peaks are the sum of the contributions of the main switching frequencies, the harmonics and the mixed frequencies.

6 Changing the switching frequency

6.1 Increasing the switching frequency

Shifting to higher switching frequencies will push the largest frequency spikes into the low frequency band [15-300kHz]. (As shown below it is not possible to shift the switching frequency above 300 kHz.) However higher switching frequencies allows maximizing the efficiency of the input filter capacitors, and may offer a BOM cost reduction especially for class 2 and Class 3 applications.
The switching frequency can only be increased by reducing the inductance value of L1. For instance applying 6.8uH increases the nominal switching frequency to 204kHz:

INPUT DATA		OUTPUT DATA	
Min. supply, VS	9	I coil_peak (VSmin) , A	5.30
Nom. supply, VS	13	I coil_peak (VSnom) , A	4.61
Max. supply, VS	16	I coil_peak (VSmax) , A	4.33
LED Forward Voltage, VF	3.5	Rosc, Kohm	40
Number of LEDs in series	6	Rsense, Ohm	0.07
Average current: LED , mA	700	Rshunt_CM, Ohm	0.11
Tmonoflop, uS	2.5	Min. switching frequency, kHz	154
L (the Coil), uH	6.8	Nom. switching frequency, kHz	204
		Max. switching frequency, kHz	230
		Avg. current FET (Vsmin), A	1.63
		Nom Output Capacitor Co, uF	4.4

The supply capacitors C6+C7 across the LEDs can be halved to 4.7uF (for a +/-10% ripple at 13V) compared to the 120kHz solution.

Remark that for higher switching frequency the series resistance of the FETs may have to be revised:

- Please read the below application note for a review of the different delays when using the 10803 at higher frequencies http://www.melexis.com/Assets/Automotive_LED_driver_300kHz_operation_5453.aspx
- The series resistance R7 =100 Ohm may have to be reduced to limit switching losses and heating of the FET. Mind that the increased slope will affect the EMC results in the FM radio band [40 .. 100]MH.

6.2 Reducing the switching frequency

From the low frequency band image, reducing the switching frequency by 20 kHz will shift the main peak outside the measured range, making the circuit compliant to Class 5 for this low frequency band.

7 Conclusions

This application note reviewed an Buck-Boost solution for 6 white LEDs at 700mA, as described in the MLX10803 Buck-Boost reference design application note. Conducted Emissions tests show that the used BOM is CISPR 25 Class 4 compliant. Further tuning is needed to achieve class 5. Or further cost improvements can be done if only class 2 or 3 are required.