1 Scope

The MLX10803 is designed to operate at a switching frequency below 150 kHz. At 300 kHz, switching delay introduces a supply dependency of the average LED current in the Buck topology.
This application note explains where this dependency comes from, and how to resolve it with a feed forward compensation network.

2 Theory: Switching delay

2.1 Delay due to internal propagation delay

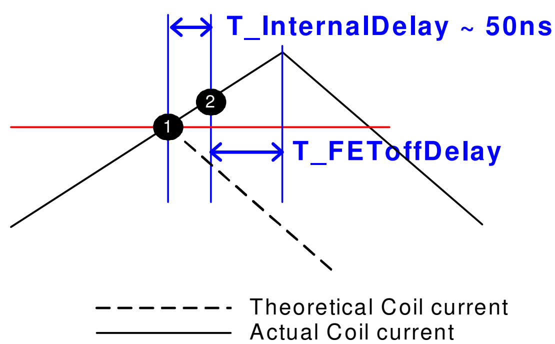


Fig 1.

In the above picture (fig 1.) the Threshold, as defined on the IREF/VREF pins, of the coil current is reached at ❶.
However the MLX10803 has an internal delay time of T_InternalDelay (~ 50ns) between the detection of the threshold on RSense (at ❶), and the actual switching of the FET on DRVOUT at ❷.

Remark:

This delay is not related to the debounce time (Tdeb ~ 300ns, see datasheet). Tdeb is designed to remove any problems due to ringing on the RSense pin.

2.2 Delay due to the falling slope of the driver FET.

The time needed to switch off the FET creates an additional delay: T_FEToff_delay.

For instance

- when using the EVB10803_1 buck evaluation board, where a SOT223 BSP318s is driven with R2 = 100 Ohm the FET turn off delay is ~300ns.

- In comparison a SOT23 PMV213SN has a smaller gate capacitance which in combination with the 100 ☐ drive resistance adds ~ 120ns delay (see fig 2.).

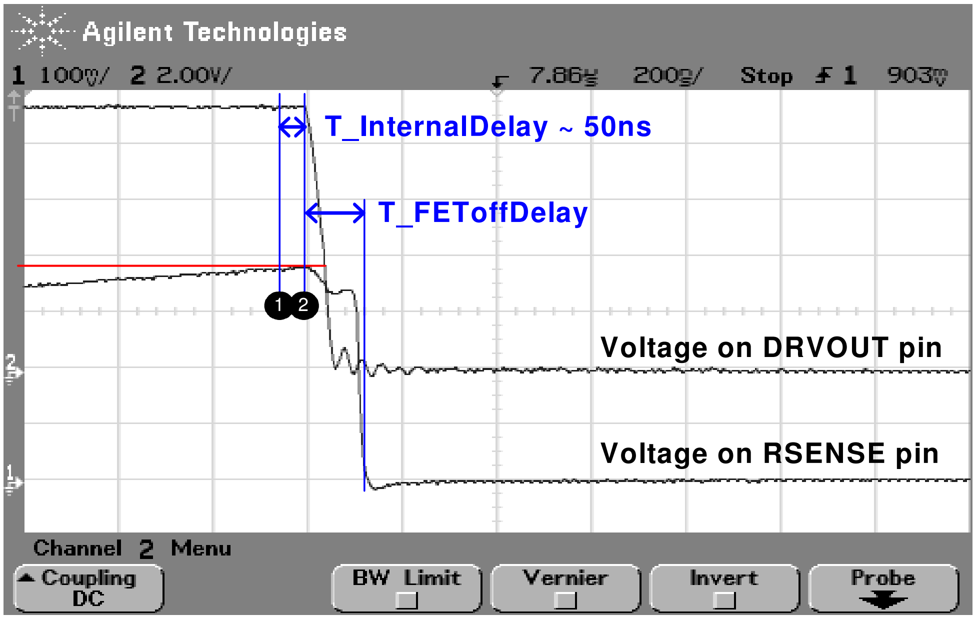


Fig 2. Switching delay with PMV213SN driven with 100 ☐ in series

2.3 Supply dependency of ILED due to the switching delay

The error on the average LED current is supply dependent:

Ierror = (Vsup - Vled)/L * T_total_offdelay

With T_total_offdelay = T_InternalDelay + T_FEToffDelay

Remarks:

- The falling edge of the FET is usually the dominant factor. Reducing T_FEToffdelay will increase the EMC noise in the FM Radio band. This noise in the FM Radio band can be improved by adding a ferrite bead in the source path of the FET.
- Increasing the inductance value L will reduce Ierror as well.

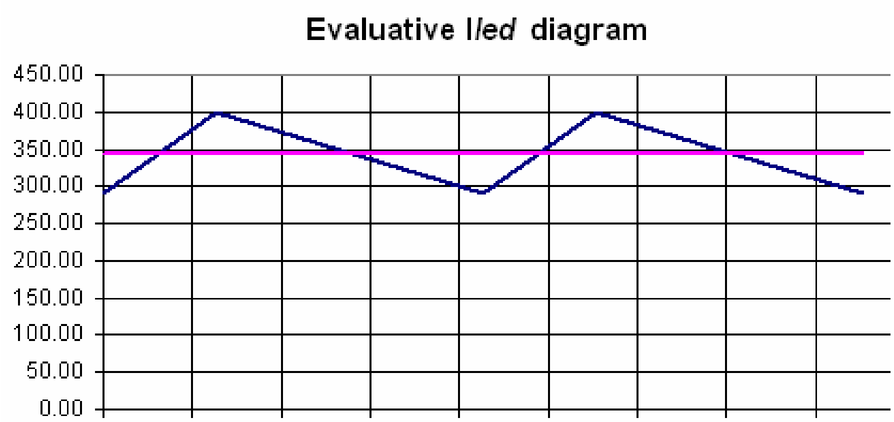
3 Application solutions

3.1 'Standard ' 150 kHz solution:

INPUT DATA	
Supply, V	13
LED threshold, V	3.5
Number of LEDs in chanel	1
Feed back diode threshold, V	0.5
Rsense, Ohm	1
Vpeak at Rsense, mV	390
Ipeak, A	0.399
Tmonoflop, uS	6
L (the Coil), uH	220

OUTPUT DATA	
The regulation is working	**good**
Coil's voltage drop	
- during charge, V	9.5
- during discharge, V	4
Lowest level of current, A	0.290
Time of discharging to 0, uS	never
Time of charging, uS	2.5
Frequency of switching, kHz	117.3
Average current: LED , A	0.344
Avg. current MLX10801 or FET	**0.10**

MLX10803 ROSC value (kOhm)	**102**
MLX10803 IREF value (kOhm)	**39**



Without any compensation network the measurement results show a small supply variation (+/-1.5%):

10V - 346mA
13V - 350mA
16V - 356mA

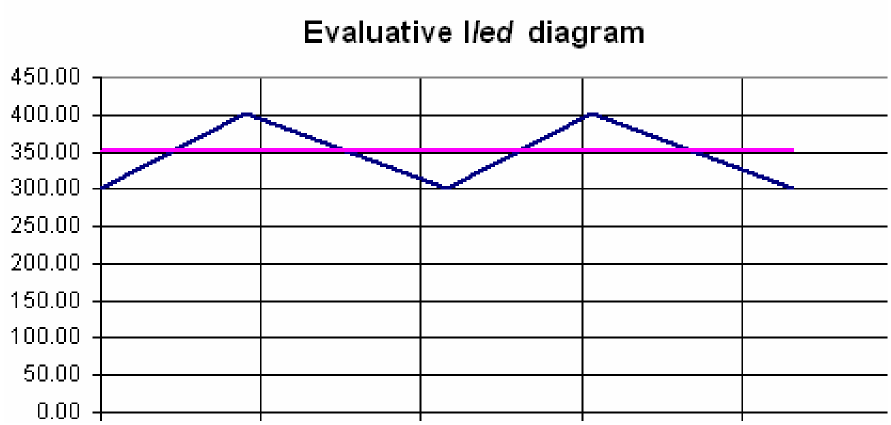
3.2 300 kHz solution:

At 300 kHz a compensation network will be required anyhow. Therefore a smaller 100 uH inductance value is selected.

INPUT DATA	
Supply, V	9
LED threshold, V	3.5
Number of LEDs in chanel	1
Feed back diode threshold, V	0.5
Rsense, Ohm	1
Vpeak at Rsense, mV	390
Ipeak, A	0.401
Tmonoflop, uS	2.5
L (the Coil), uH	100

OUTPUT DATA	
The regulation is working	**good**
Coil's voltage drop	
- during charge, V	5.5
- during discharge, V	4
Lowest level of current, A	0.301
Time of discharging to 0, uS	never
Time of charging, uS	1.8
Frequency of switching, kHz	231.6
Average current: LED , A	0.351
Avg. current MLX10801 or FET	**0.15**

MLX10803 ROSC value (kOhm)	**40**
MLX10803 IREF value (kOhm)	**39**



The below table shows how to measurement results with and without a resistive compensation network for the below application schematic:

Vin (V)	Iavg(mA)_uncompensated	Iavg(mA)_compensated
9	329	342
10	338	345
11	342	346
12	347	347
13	353	348
14	357	349
15	362	350
16	366	352
Error 10-16V	28 mA	7 mA
+/- %	**+/-4%**	**+/-1%**

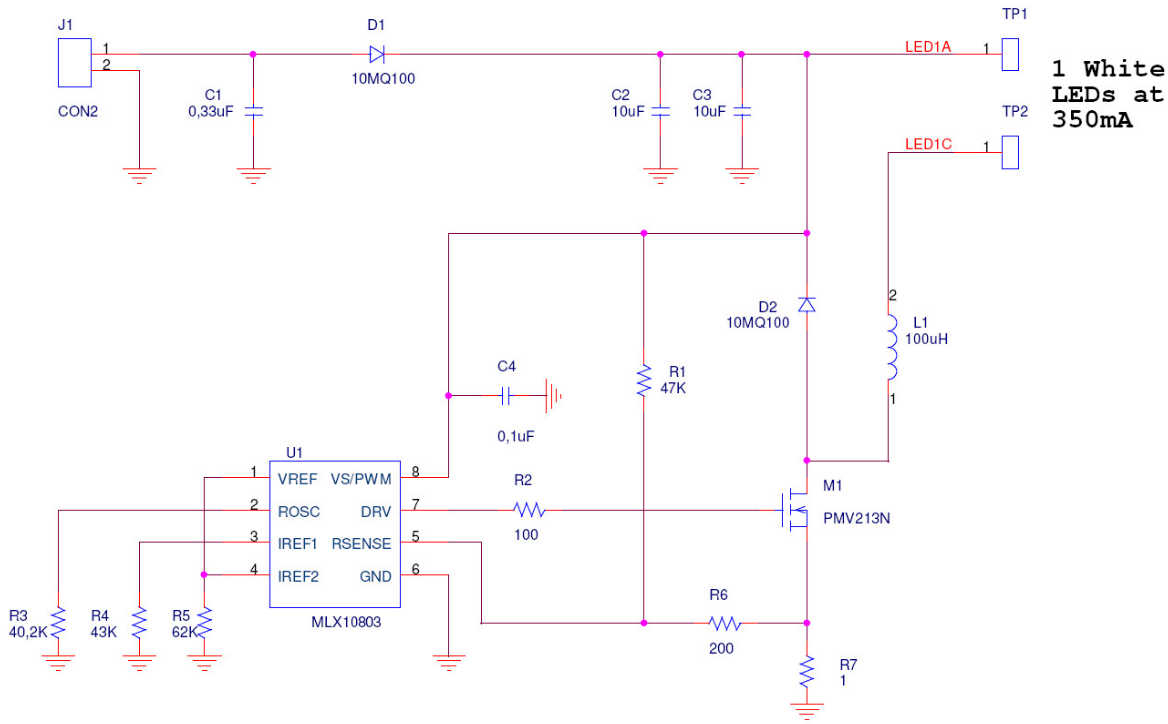


Fig 3. Application Schematic

Compensation is achieved by adding a supply dependant voltage on top of the voltage over Rsense (R7). This increases the voltage on the RSENSE input pin when the supply voltage rises. This lowers the peak-current threshold when the supply voltage rises, stabilizing the LED current.

Practical implementation is done by adding 2 resistors R1 and R6. This creates a compensation current which is approximated by

Ivcmp = -[R6/(R6+R1) x Vs]/ R7

The current compensation slope is determined by - R6/(R6+R1) , which can be targeted to compensate the ILED rise due to the nonzero switch-off delay. It will require some experimenting to find the correct values.

The below application schematic the following compensation network has reduced the supply dependency to less than +/-1%:

- R1 = 47K between pin 8 and pin 5 MLX10803.
- R6 = 200 Ω resistor between R3 and pin 5 MLX10803.

4 Influence of the randomisation of the off time on the spectral plot

The application note on the randomisation:
http://www.melexis.com/Assets/Automotive_LED_driver_Randomisation_and_Frequency_Selection_5466.aspx
explains that due to the randomisation of the off time (Toff) the spectral distribution caused by the switching of the MLX10803 is extending below the nominal switching frequency.

From this it is clear that shifting the nominal switching frequency to 300 kHz does not remove the noise from the low frequency band. Nevertheless it is possible to pass 3W class2 and even class 3 applications without input filter coil.

5 Conclusion

The MLX10803 can be used in the 300 kHz range. For the buck topology an additional resistor should be implemented to compensate for the influence of the switching delay. This switching delay is mainly dependent from the time required to switch off the FET.