AN2052
APPLICATION NOTE

VIPower: IMPLEMENTING FREQUENCY MODULATION ON VIPer53 TO IMPROVE THE EMI EMISSIONS

ABSTRACT

This report describes how the frequency modulation reduces electromagnetic interference on an SMPS using Viper53 as primary PWM-switch.

For your reference, comparison of EMI measurement data will be presented.

1. TEST RESULTS

Figure 1: Original, time average at 200kHz, 53.42dBuV/m

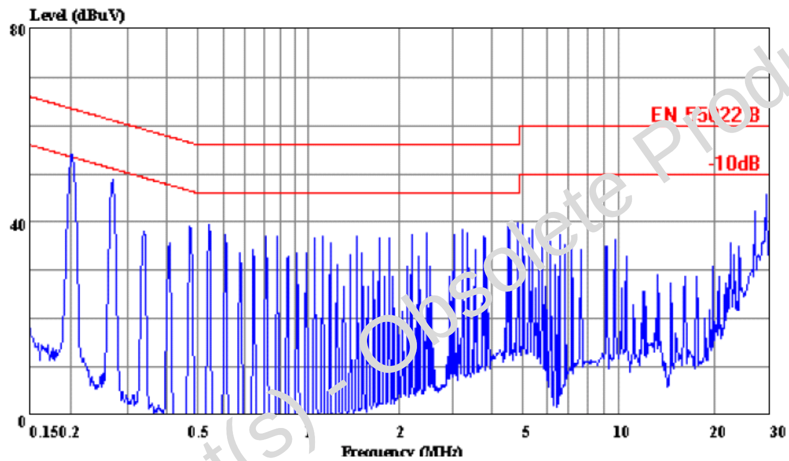


Figure 2: FM configuration "A", time average at 200kHz, 48.07dBuV/m

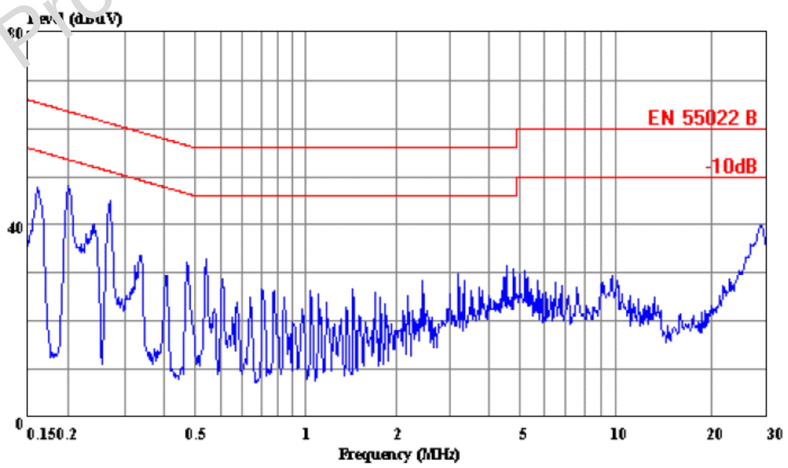
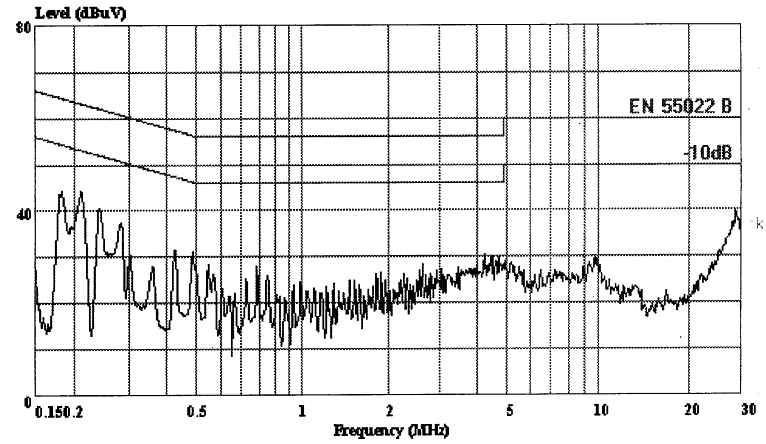


Figure 3: FM configuration "B", time average at 200kHz, 43.92dBuV/m



As shown in figures 1, 2 and 3, using the FM technique a margin improvement will be obtained. At frequencies lower than 1MHz, the device switching is the primary noise generator. Using the configuration "A" or "B" a 5 dBuV/m drop is obtained for frequencies lower than 200kHz.

Between 1MHz and 10MHz, both configuration "A" and "B" make a dramatic drop greater than 15dBuV/m. Above 10MHz, FM technique benefits are reduced and capacitive coupling between copper tracks in PCB is dominant.

Table 1:

	<1MHz	1Mhz ~ 10MHz	>10MHz
Original	Marginally pass	Pass	Enough margins
“A”	Pass	More margins	Enough margins
“B”	More margins	More margins	Enough margins

2. CIRCUIT AND DESCRIPTION OF TEST CONFIGURATIONS

Figure 4: Original configuration (Fixed frequency at 70 kHz, and no FM).

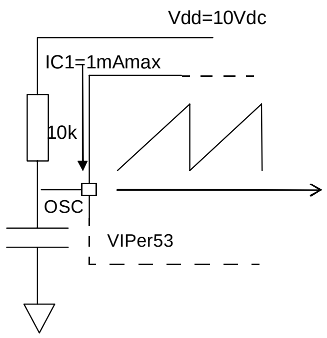


Figure 5: Configuration "A" (Switching frequency from 63kHz to 77kHz FM cycle 20ms, 50Hz).

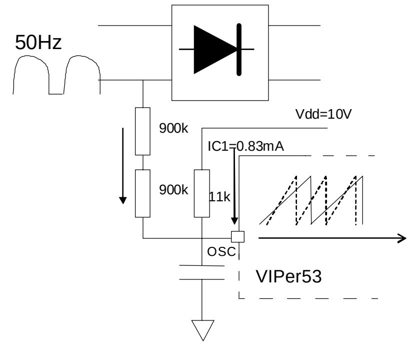
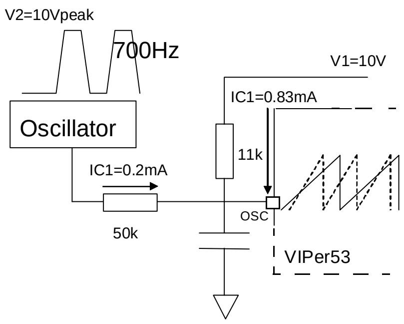


Figure 6: Configuration "B" (Frequency from 63 kHz to 77 kHz, FM cycle 1.4ms, 700Hz).



Changing the resistor value between Vdd and OSC pin, it is possible to modify the frequency oscillator (capacitor value is fixed at 220nF). In this way the FM percentage can be set. The target FM percentage is +/-10%. In the original circuit a 10kohm resistor is used, obtaining a switching frequency of 70 kHz. This resistor value gives a charging current capacitor of 1mA max.

The external circuit works in order to increase the switching frequency. Therefore, it is necessary to change the resistor value between Vdd and OSC pin in order to reduce minimum switching frequency to 66KHz. As a result the new resistor value will be 11kohm, obtaining a charging current of 0.9mA when external voltage is 0V. The switching frequency variation depends on the charging current capacitor, therefore it is proportional to the external voltage. Maximum value of the switching frequency is 77 kHz: it is obtained when the charging current is 1.1mA where 0.9mA is given by Vdd and 0.2mA is supplied from the external circuit.

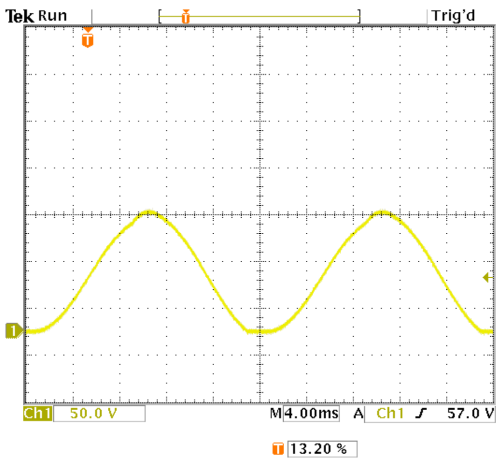
Below, the design of the resistor value, between OSC pin and the oscillator, is explained:

- in configuration "A", maximum voltage is 374V, so the resistance is R=373V/0.2mA =1.8Mohm;
- in configuration "B", the maximum voltage is 10V, so the resistance is R=10V/0.2mA =50kohm.

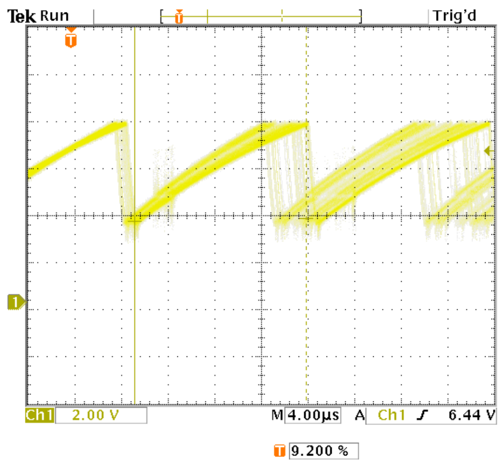
It is important to verify the frequency obtained using the oscilloscope. If necessary this frequency value will have to be tuned to the desired value.

In figures 7 and 8, the typical clock signal is shown.

Figure 7: Configuration "A".

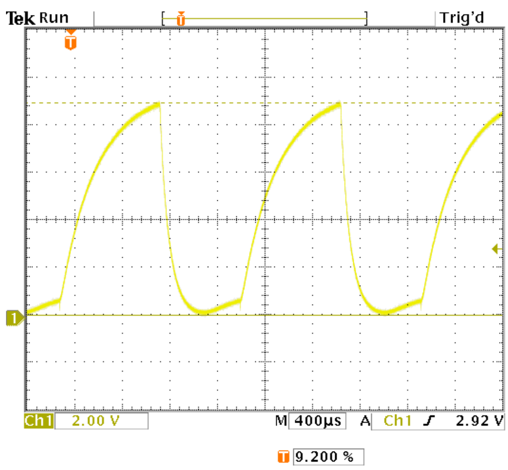


AC signal (50Hz oscillator)

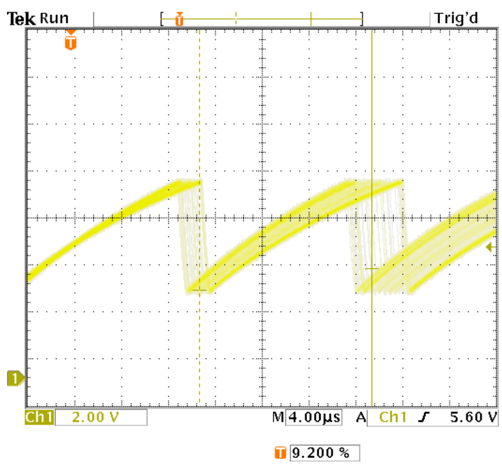


PWM ramp signal

Figure 8: Configuration "B".



Oscillator signal (700Hz oscillator)



PWM ramp signal

3. ANALYSIS AND POSSIBLE FURTHER DEVELOPMENT

In figures 9, 10 and 11 the peak value data of the three tested configurations are shown.

Figure 9: Original peak.

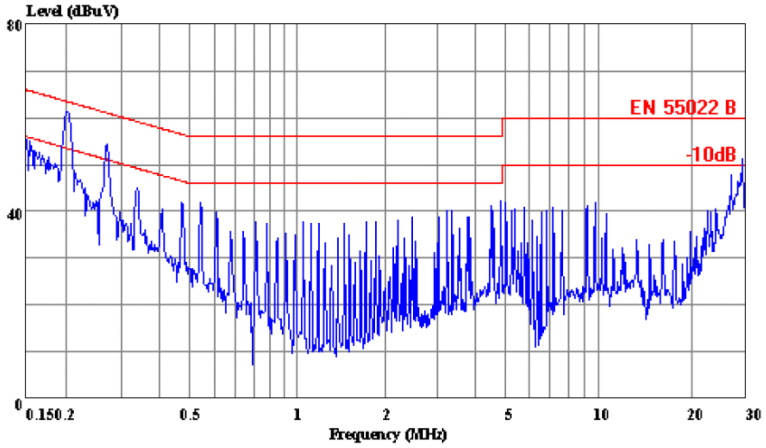


Figure 10: Configuration “A” peak.

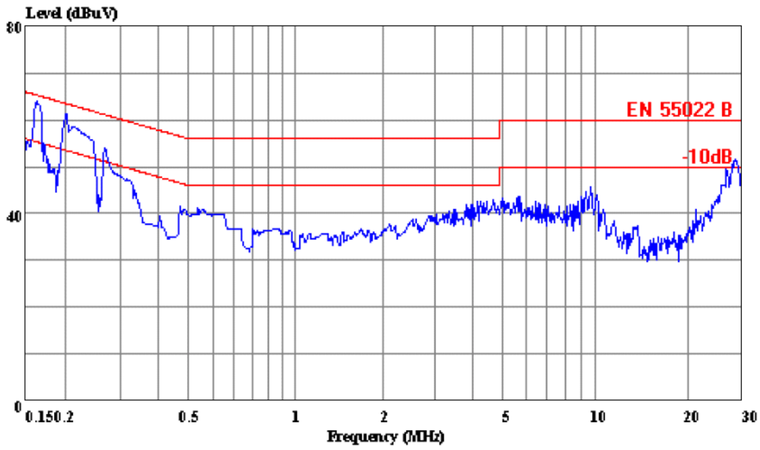
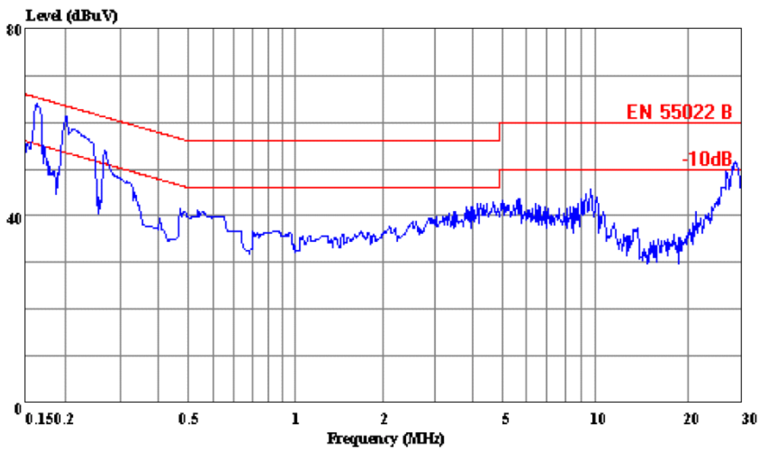


Figure 11: Configuration “B” peak.



One remarkable point is that the peak value of the three tested configurations is almost the same.

The major difference between peak and average measurement is in the filter and in the measurement time. Wide band filter and short measurement time are used to capture the peak value; while narrow band filter and relatively long measurement time are used to capture the average value.

Through web search engines it is possible to find the definitions for the terms "peak" and "average" as "spectrum peak" and "spectrum average", respectively. These definitions are different from the "time-peak" and "time-average" defined in this report.

Instead, the term "frequency modulation" can be found on the web as "spread spectrum",

The spectrum peak is the highest component over the frequency spectrum. In EMI test data of SMPS, it corresponds to a low frequency.

The spectrum average is the average noise over the whole frequency spectrum.

The time peak is the "peak" data measured by most EMI test lab. Noise, in terms of dBuV/m, is measured through a wide band filter within a short period of time.

Analysing such measurements, the fact that FM does not bring benefit is highlighted. The measurements obtained are very similar to the spectrum envelope of figure 9.

The time average is the "average" data measured by EMI test lab. Noises are measured through a narrow band filter, over a relatively long period of time.

Note that there is no regulation on the measurement average time.

4. OPTIMIZATION OF EXTERNAL OSCILLATOR

Targeted to lower down the average value of EMI noise, the PWM must go through the whole frequency range within the testing time. In other words, the FM cycle is as short as possible. On the other hand, since the actual PWM signal is modulated by the FM cycle and switching cycle, to avoid audible noise, FM frequency is suggested to be lower than 2 kHz.

This also accounts for the fact that the average data of configuration "B", 700Hz oscillator, is lower than the configuration "A", 50Hz oscillator.

Another drawback of configuration "A" is the dependency on AC mains, which can be an issue in transformer design.

5. REFERENCE

Oscillator with 2 BJTs., low cost and startup volutage down to 3V.