AND8477/D

P6P82PS01A: A "Drop-In" Active EMI Reduction IC For AC-DC and DC-DC Power Converters

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APPLICATION NOTE

Abstract

PWM based converters are widely used in AC−DC, DC−DC power management applications. While PWM converters offer better efficiency and load/line regulation compared to linear regulators, PWM converters exhibit significant input EMI caused by the switching components. Input EMI filters are widely used to suppress and/or eliminate the EMI fed back to the input stage. Spread Spectrum (SS) technology, a method to dither the switching frequency over a wider frequency bandwidth is a powerful alternate EMI solution. ON Semiconductor introduces P6P82PS01A: A companion IC that can be dropped−in on to the frequency control node in a PWM controller, such as RT, or RT−CT nodes. This companion IC is targeted towards applications that employ AC−DC and DC−DC converters. Unlike EMI filters, P6P82PS01A offers better EMI reduction at the higher harmonics of the switching frequency. This application note compares EMI performance of EMI filters when compared to P6P82PS01A using Spread Spectrum technology.

Introduction

Switching in PWM converters causes input noise on both line and neutral nodes at the input stage. This noise manifests itself across the harmonics of the switching frequency. Regulatory agencies such as FCC and CISPR specify the compliance limits of this noise and the test procedures. The conducted emissions test specifications arise from the fact that these input noise harmonics cause unwanted electro−magnetic radiation when they traverse through a long cable (typically 1 m or longer). Bulk EMI filters at the input side are used to reduce this noise. There are two challenges in using EMI filters:

1. Any practical EMI filter is affected by unwanted parasitics. This degrades the filter performance and hence, a given EMI filter is effective only in a band of frequencies.
2. Adding EMI filters is a potential stability concern. Hence, some EMI filter configurations may not be feasible to realize.

Due to the concerns listed above, multiple EMI filters are used to reduce EMI over a broad range of frequencies (100 kHz − 400 kHz to 30 MHz) under which conducted emissions tests are performed.

SS technology inherently offers better reduction at higher frequency harmonics and can serve as a single EMI solution over a broader range of frequencies. Moreover, there is no stability concern due to SS.

However, to achieve optimal EMI reduction from SS ,an optimal combination of key SS parameters such as modulation rate, deviation, and modulation profile needs to be chosen for a given switching frequency. ON Semiconductor offers P6P82PS01A that can be used as a drop in companion IC on to a frequency−controlling node in a PWM converter. This device offers full flexibility to select the optimal modulation rate and deviation to achieve optimal EMI reduction.

P6P82PS01A can either reduce or eliminate the input EMI filter and offer EMI reduction, with no impact on system stability. This application note focuses on P6P82PS01A versus Input EMI filters over a range of switching frequencies.

P6P82PS01A IC :

P6P82PS01A IC is targeted for RT/RT−CT based PWM controllers. P6P82PS01A is optimized for linear Modulation profile and provides the flexibility to control the deviation by varying the resistance at the SSEXTR pin (Pin 5). P6P82PS01A provides flexibility to control the modulation rate by :

1. Keeping MRSEL (Pin 7) pin low for internal Modulation rate control.
2. Keeping MRSEL (Pin 7) pin high for external Modulation rate control.
3. Internal modulation rate is controlled by varying a resistance at the MREXTR pin (Pin 2), when MRSEL (Pin 7) is low.
4. An external clock at the MREXTR pin (Pin 2) provides external modulation rate, when MRSEL (Pin 7) is high.

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As shown in Figure 2, the RT/RT−CT pin of P6P82PS01A should connect to the RT/RT−CT pin of PWM controller.

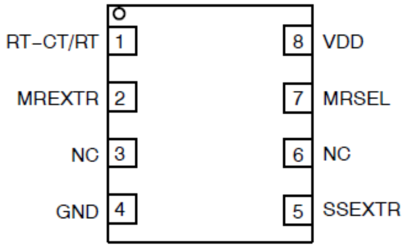

Figure 1. Pin Configuration of P6P82PS01A IC

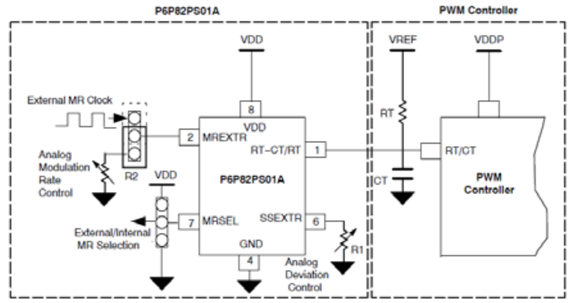

Figure 2. Application Schematic Circuit For P6P82PS01A

Table 1. PIN DESCRIPTION

Pin	Pin Name	Type	Description
1	RT/RT−CT	I/O	Input /Output pin connected to RT/RT−CT pin of PWM controller
2	MREXTR	I	Selects Analog Modulation Rate through external resistor to GND when MRSEL pin pulled LOW. When MRSEL pin pulled HIGH, an external clock can be fed in to this pin. Has no default state.
3	NC		Not connect
4	GND	P	Ground
5	SSEXTR	I	Analog Deviation selection through external resistor to GND.
6	NC		Not connect
7	MRSEL	I	Modulation Rate Select. Selects Analog modulation clock when pulled LOW. Selects an External Modulation clock fed through MREXTR pin, when pulled HIGH. Has an internal pull−down resistor.
8	VDD	P	3.3 V supply voltage.

P6P82PS01A in an AC−DC Converter Application

This case study is based on 3844 PWM controller with an RT−CT node to control PWM frequency. By changing RT, CT or both, PWM frequency can be varied.

Capacitors C5, C6 are input EMI filters, shown in Figure 3. As shown in Figure 4, P6P82PS01A is added at the RT−CT node of PWM controller.

System Performance

Results from Table 2 show that system performance parameters like Ripple voltage, Mean output voltage and Efficiency are not impacted significantly with P6P82PS01A.

Table 2. SYSTEM PERFORMANCE AT 50 kHz SWITCHING FREQUENCY

Test	With EMI Filters	With P6P82PS01A	No EMI Filters
Output Voltage (V)	12.04	12.04	12.04
Ripple Voltage (mV)	200	300	275
Efficiency at 0.5 A Load	37.04%	37.59%	37.59%
Efficiency at 0.9 A Load	43.69%	44.55%	44.33%

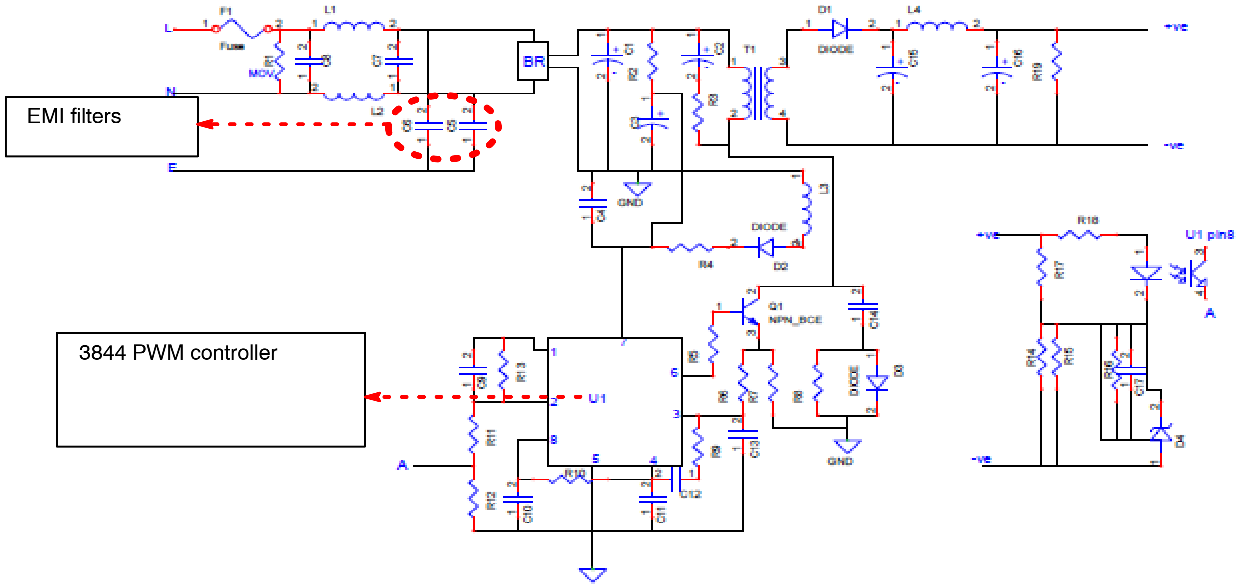

Figure 3. AC to DC Converter Schematic Diagram

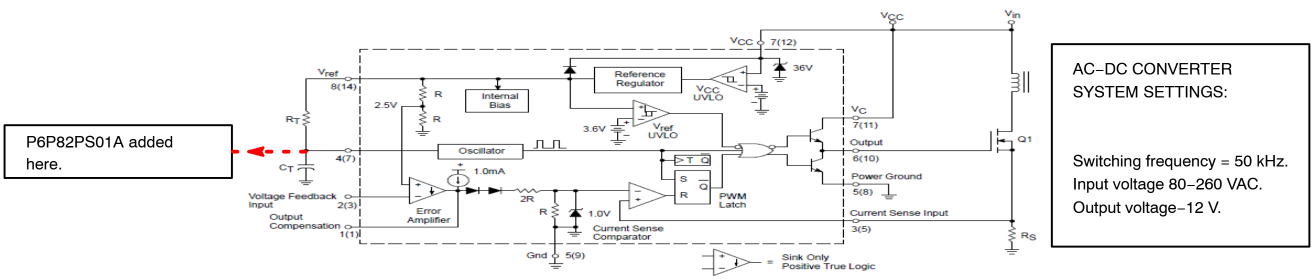

Figure 4. 3844 PWM Controller Schematic Diagram

EMI PERFORMANCE

Test settings:

CE scan setting: CISPR−22, CLASS B standard in AVERAGE mode on LINE.

P6P82PS01A device settings: MR = 12 kHz, %SPREAD = ±20.

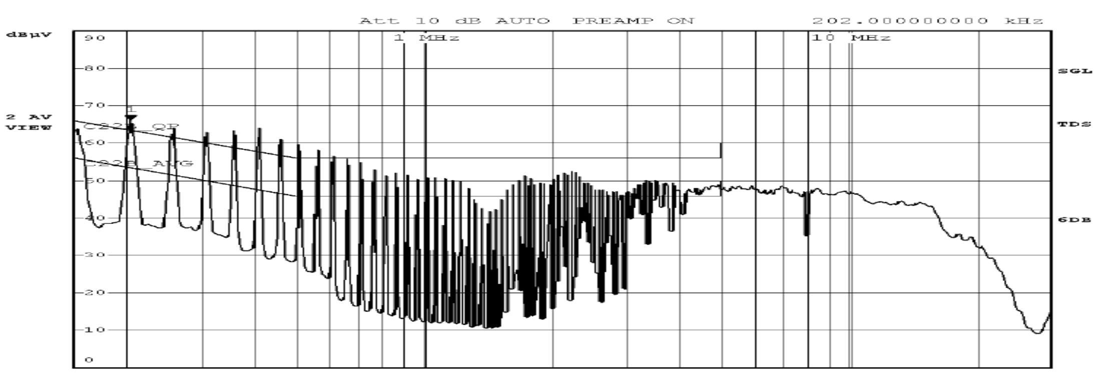

Figure 5. Original EMI

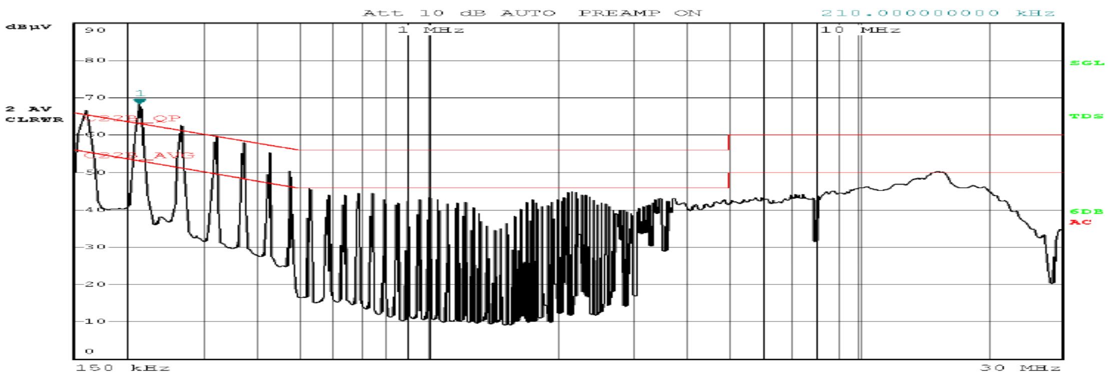

Figure 6. With Filters

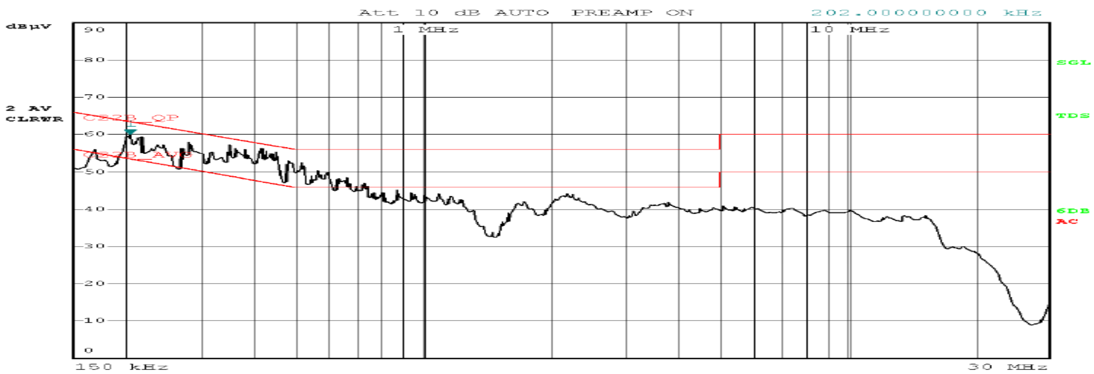

Figure 7. With P6P82PS01A

Table 3. EMI REDUCTION TABLE

Frequency (kHz)	Original EMI (dBuV)	With EMI Filters (dBuV)	With P6P82PS01A (dBuV)	Reduction With EMI Filters (dBuV)	Reduction With P6P82PS01A (dBuV)
150	64	66	56	–2	8
200	66	68	59	–2	7
250	65	63	56	2	9
300	63	59	58	4	5
350	64	58	57	6	7
400	64	55	56	9	8
450	61	50	53	11	8
500	59	45	52	14	7
1000	51	44	44	7	7
2000	50	43	40	7	10
4000	48	42	40	6	8
5000	48	43	41	5	7
9000	47	45	39	2	8
10000	47	46	39	1	8
15000	45	50	38	–5	7
20000	32	45	28	–13	4
30000	15	35	15	–20	0

Results from Table 3, Figures 5, 6 and 7, show that P6P82PS01A gives better EMI reduction compared to EMI filters.

P6P82PS01A IN an DC−DC CONVERTER application:

This case study is based on TPS54317, a 1.6 MHz, 3 V to 6 V input, 3 A synchronous step−down swift converter. It has an Adjustable output voltage from 0.9 V to 2.5 V. Operating frequency range is 280 kHz to 1.6 MHz, controlled by the timing resistor (RT) (R4 in Figure 8).

As shown in Figure 8, capacitor C1, C12, C13, C14 are input EMI filters and P6P82PS01A is added at the RT node of PWM controller.

System Performance

Results from Tables 4 and 5, show that system performance parameters like Ripple voltage, Mean output voltage, and Efficiency are not impacted significantly with P6P82PS01A at 280 kHz and 1 MHz PWM frequencies.

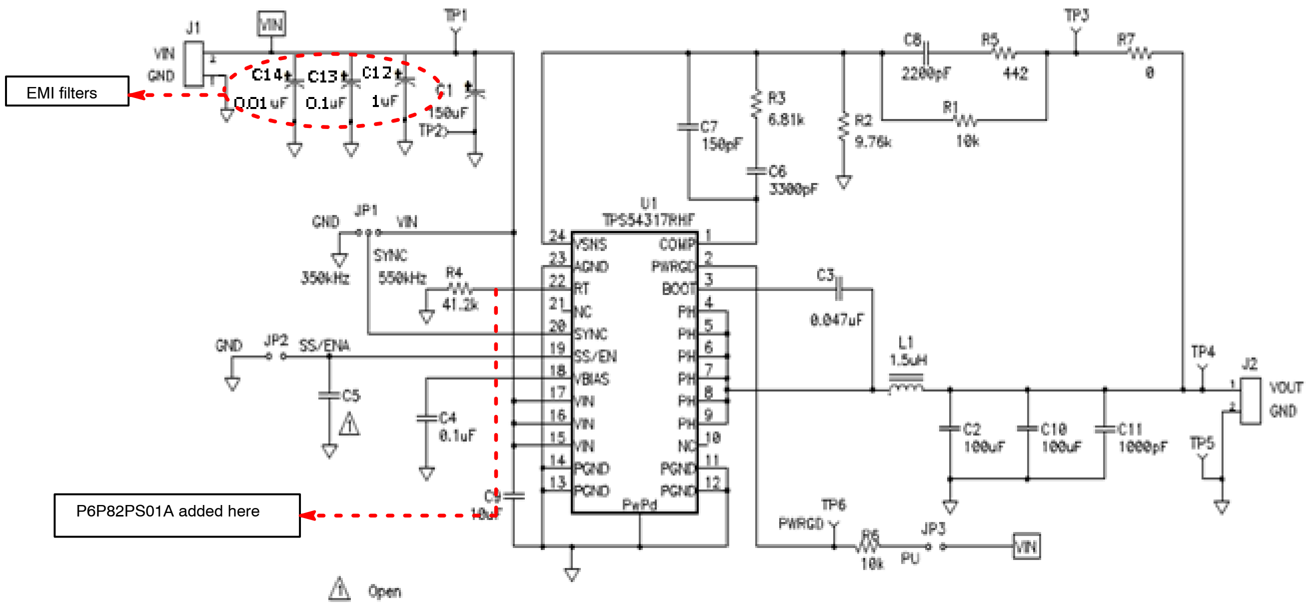

Figure 8. TPS54317−EVM Schematic Diagram

Table 4. SYSTEM PERFORMANCE AT 1 MHz

Test	With EMI Filters	With P6P82PS01A	No EMI Filters
Output Voltage (V)	2.428	2.427	2.426
Ripple Voltage (mV)	290	296	270
Efficiency at Load of 0.5 A	91.74%	91.66%	91.66%
Efficiency at Load of 1.5 A	87.15%	86.47%	86.5%

Table 5. SYSTEM PERFORMANCE AT 280 kHz

Test	With EMI Filters	With P6P82PS01A	No EMI Filters
Output Voltage (V)	2.427	2.426	2.426
Ripple Voltage (mV)	530	640	550
Efficiency at Load of 0.5 A	89.69	91.82%	89.54%
Efficiency at Load of 1.5 A	87.34%	87.96%	87.96%

EMI Performance

Test settings:

CE scan setting: CISPR−22, CLASS B standard in AVERAGE mode on LINE.
P6P82PS01A device settings: MR = 25 kHz, %SPREAD = ±20.

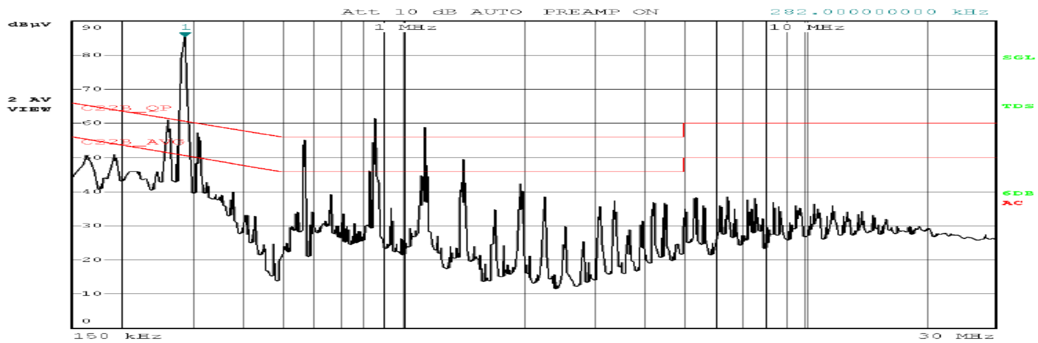

Figure 9. Original EMI AT 280 kHz PWM Frequency

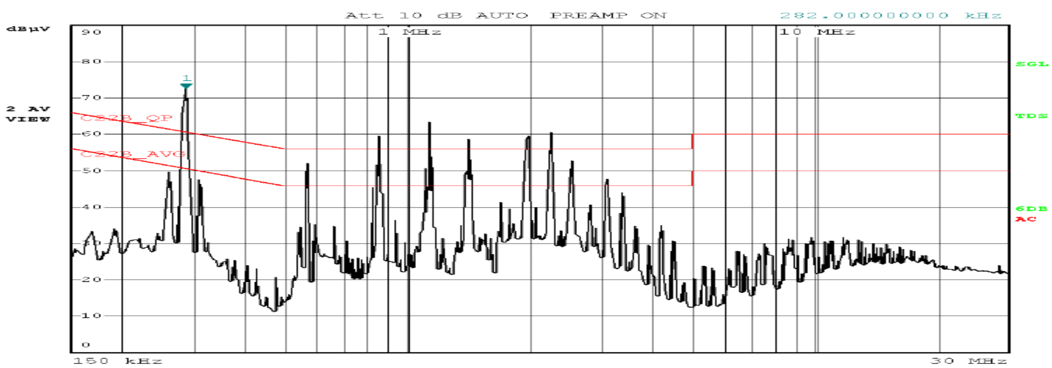

Figure 10. With Filters at 280 kHz PWM Frequency

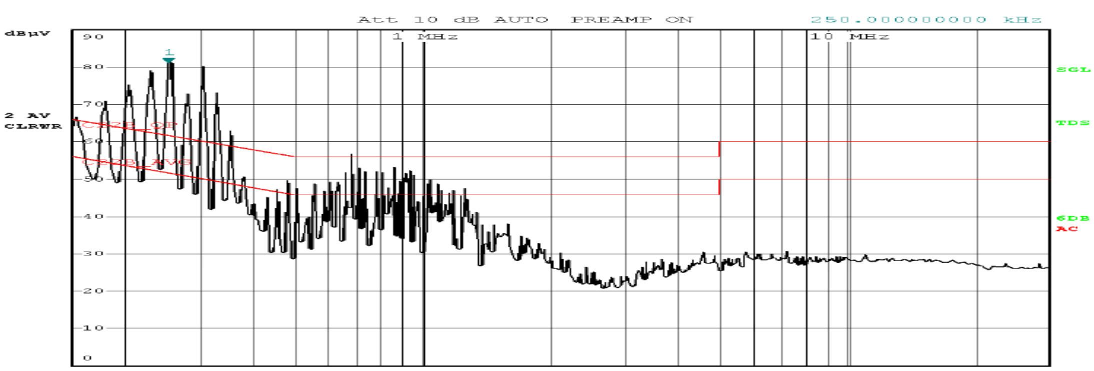

Figure 11. With P6P82PS01A at 280 kHz PWM Frequency

Table 6. EMI REDUCTION TABLE AT 280 kHz

Frequency (kHz)	Original EMI (dBuV)	With EMI Filters (dBuV)	With P6P82PS01A (dBuV)	Reduction With EMI Filters (dBuV)	Reduction With P6P82PS01A (dBuV)
280	86	72	82	14	4
560	55	52	48	3	7
840	62	59	53	3	9
1120	59	64	48	–5	11
1400	49	58	47	–9	2
1680	35	42	38	–7	–3
1960	42	59	36	–17	6
2240	39	60	30	–21	9
2520	30	52	26	–22	4
2800	25	41	24	–16	1
3080	36	47	25	–11	11
5040	35	20	28	15	7
10080	36	30	30	6	6
15120	35	30	28	5	7
20160	28	24	27	4	1
29960	27	22	27	5	0

Results from the Table 6, Figures 9, 10 and 11, show that P6P82PS01A gives better EMI reduction compared to EMI filters.

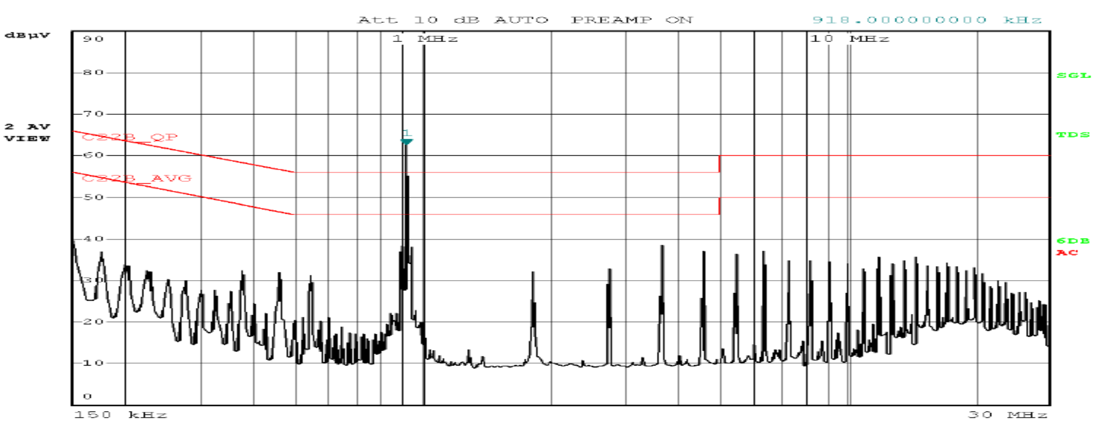

Figure 12. Original EMI AT 1 MHz PWM Frequency

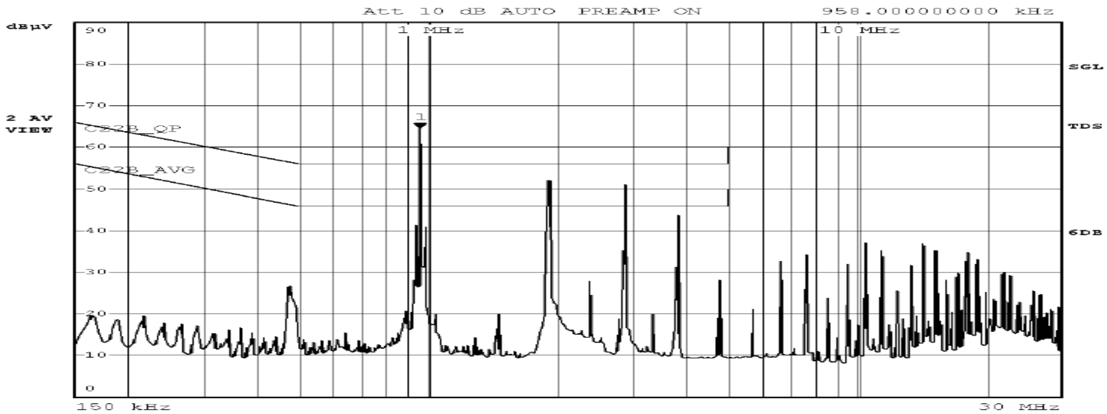

Figure 13. With Filters at 1 MHz PWM Frequency

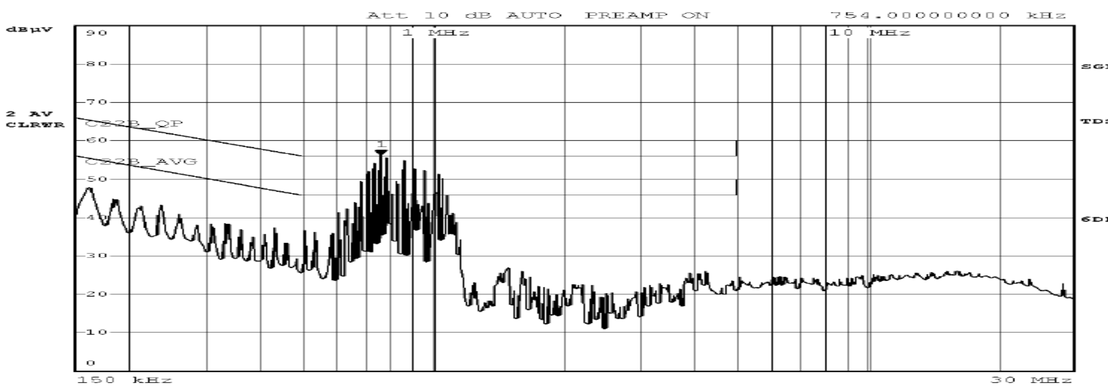

Figure 14. With P6P82PS01A at 1 MHz PWM Frequency

Table 7. EMI REDUCTION TABLE AT 1 MHz

Frequency (MHz)	Original EMI (dBuV)	With EMI Filters (dBuV)	With P6P82PS01A (dBuV)	Reduction With EMI Filters (dBuV)	Reduction With P6P82PS01A (dBuV)
1	63	66	57	–3	6
2	32	52	26	–20	6
3	32	51	23	–19	9
4	38	44	23	–6	15
5	37	28	26	9	11
6	37	21	24	16	13
7	38	32	24	6	14
8	35	34	24	1	11
9	35	24	24	11	11
10	35	32	24	3	11
15	35	37	26	–2	9
20	32	25	24	7	8
30	25	22	19	3	6

Results from Table 7, Figures 12, 13 and 14, show that P6P82PS01A gives better reduction compared to filters.

Summary

At three different PWM frequencies in both DC−DC as well as AC−DC converters, it can be observed that P6P82PS01A can be used as an effective active EMI reduction solution. In all the cases, especially at the higher harmonics, the performance of P6P82PS01A is superior to EMI filters (input EMI filters for DC−DC and common mode EMI filters for AC−DC converters).

Moreover, P6P82PS01A also reduces the BOM and saves PCB space (2 mm x 2 mm package vs. bulk capacitances and inductances).

In this application note, the deviation setting was ±20% in all case studies. However, P6P82PS01A provides flexibility to control the deviation other than ±20% to suit EMI performance and system performance requirements. Given its flexibility in controlling the key SS parameters, P6P82PS01A is the ideal EMI solution to pass conducted EMI compliance tests and can be used to reduce, if not eliminate, EMI filters.

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