Application Report
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CISPR25 Radiated Emissions Using TLV62065-Q1

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ABSTRACT

This application note summarizes the CISPR25 Radiated Emission test results of the evaluation module (EVM), HVL119. The EVM is based on the TLV62065-Q1 device, a low-voltage and high switching-frequency buck converter. The EVM showed good performance, and passed CISPR25 Radiated Emission Class 5 limits through all tests. This report includes the EMI test results as well as the schematic, bill of materials (BOM), layout, and printed circuit board (PCB) specifications.

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1 Schematics and Printed Circuit Board Description

The HVL119 EVM is designed with the purpose of passing the automotive-specific CISPR25 Class 5 Radiated Emission test. The EVM is based on the TLV62065-Q1 device which is a DC-DC buck converter that operates with a switching frequency of 3 MHz and an adjustable output voltage. For this design, the output voltage is configured to 1.8 V. Table 1 lists the electrical specifications of the EVM.

To improve the EMI performance of the device, an input filter is added to attenuate noise generated by the converter on the input voltage node. A snubber, together with a clamping diode, is added to the switching node of the device to attenuate high frequency components.

Table 1. Electrical Specification of HVL119

Parameter		Value
V_{IN}	Input voltage range	2.9 to 5.5 V
V_{OUT}	Output voltage	1.8 V
I_{OUTmax}	Maximum output current	2 A
f_{SW}	Switching frequency	3 MHz

1.1 Schematic and Bill of Materials for HVL119

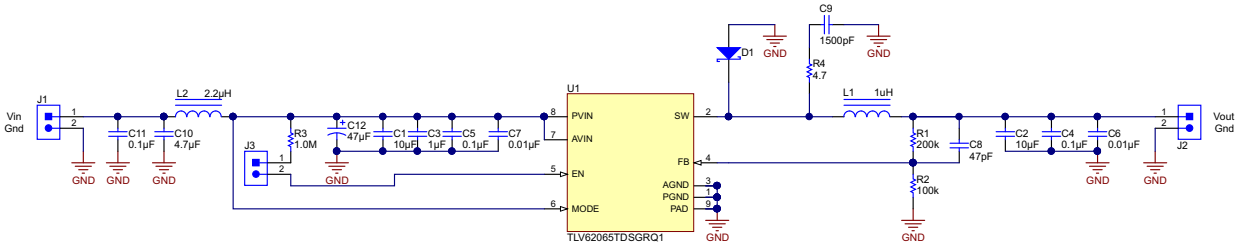

Table 2. Bill of Material for HVL119

Designator	Qty	Value	Description	Package	Part Number	Manufacturer
!PCB	1		Enverything populated			Any
C1, C2	2	10 µF	CAP, CERM, 10 µF, 10 V, ± 10%, X7R, 0805_140	0805_140	GCM21BR71A106KE22L	MuRata
C3	1	1 µF	CAP, CERM, 1 µF, 16 V, ± 10%, X5R, 0402	0402	EMK105BJ105KVHF	Taiyo Yuden
C4, C5, C11	3	0.1 µF	CAP, CERM, 0.1 µF, 16 V, ± 10%, X7R, 0402	0402	GCM155R7IC104KA55D	MuRata
C6, C7	2	0.01 µF	CAP, CERM, 0.01 µF, 50 V, ± 10%, C0G/NP0, 0402	0402	GCM155R71H103KA55D	MuRata
C8	1	47 pF	CAP, CERM, 47 pF, 50 V, ± 5%, C0G/NP0, 0402	0402	UMK105CG470JVHF	Taiyo Yuden
C9	1	1500 pF	CAP, CERM, 1500 pF, 16 V, ± 10%, X7R, 0603	0603	CGA1A2X7R1C152K030 BA	TDK
C10	1	4.7 µF	CAP, CERM, 4.7 µF, 10 V, ± 10%, X7R, 0805	0805	GRM21BR71A475KA73L	MuRata
C12	1	47 µF	CAP, AL, 47 µF, 16 V, ± 20%, 0.7 ohm, SMD	SMT Radial C	EEE-FK1C470UR	Panasonic
D1	1	30 V	Diode, Schottky, 30 V, 0.5 A, SOD-123	SOD-123	B0530W-7-F	Diodes Inc.
J1, J2	2		Terminal Block, 6 A, 3.5-mm Pitch, 2-Pos, TH	7×8.2×6.5 mm	ED555/2DS	On-Shore Technology
J3	1		Header, 100 mil, 2×1, Tin, TH	Header, 2 PIN, 100 mil, Tin	PEC02SAAN	Sullins Connector Solutions
L1	1	1 µH	Inductor, Shielded, Powdered Iron, 1 µH, 2.5 A, 0.063 Ω, SMD	2.5×1×2 mm	78438323010	Wurth Elektronik eiSos
L2	1	2.2 µH	Inductor, 2.2 µH, 1.8 A, 0.094 Ω, SMD	SMD, 2-Leads, Body 3x3mm	78438335022	Wurth Elektronik eiSos
R1	1	200 kΩ	RES, 200 kΩ, 1%, 0.063 W, 0402	0402	CRCW0402200KFKED	Vishay-Dale
R2	1	100 kΩ	RES, 100 kΩ, 1%, 0.063 W, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R3	1	1 MΩ	RES, 1 MΩ, 5%, 0.063 W, 0402	0402	CRCW04021M00JNED	Vishay-Dale
R4	1	4.7 Ω	RES, 4.7 Ω, 5%, 0.063 W, 0402	0402	CRCW04024R70JNED	Vishay-Dale
U1	1		3-MHz 2-A Step-Down Converter, DSG0008A	DSG0008A	TLV62065TDSGRQ1	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A

1.2 PCB Layout

The EVM is manufactured on a two-layer FR4 PCB that is 33 mm × 40.5 mm with a substrate thickness of 0.8 mm. The bottom ground plane is placed in the second layer as close as possible to top routing layer. This technique is used to minimize the AC loop inductance. Figure 1, Figure 2, and Figure 3 show the component placement and layout.

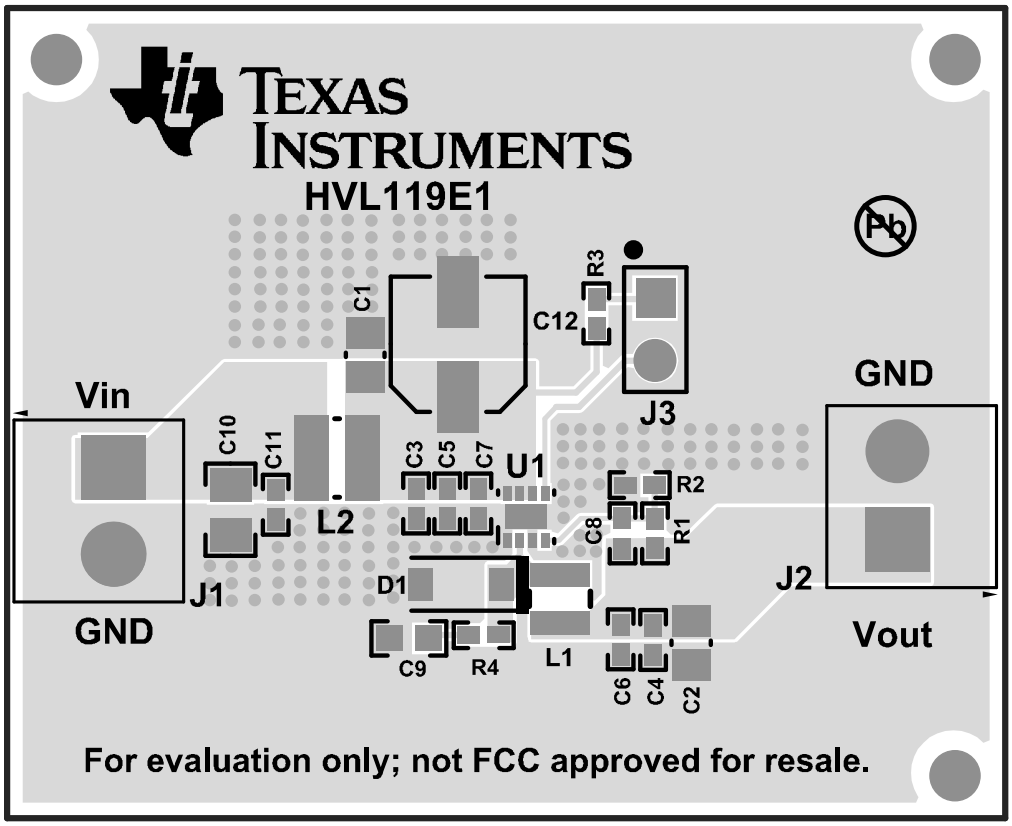

Figure 1. PCB Top View

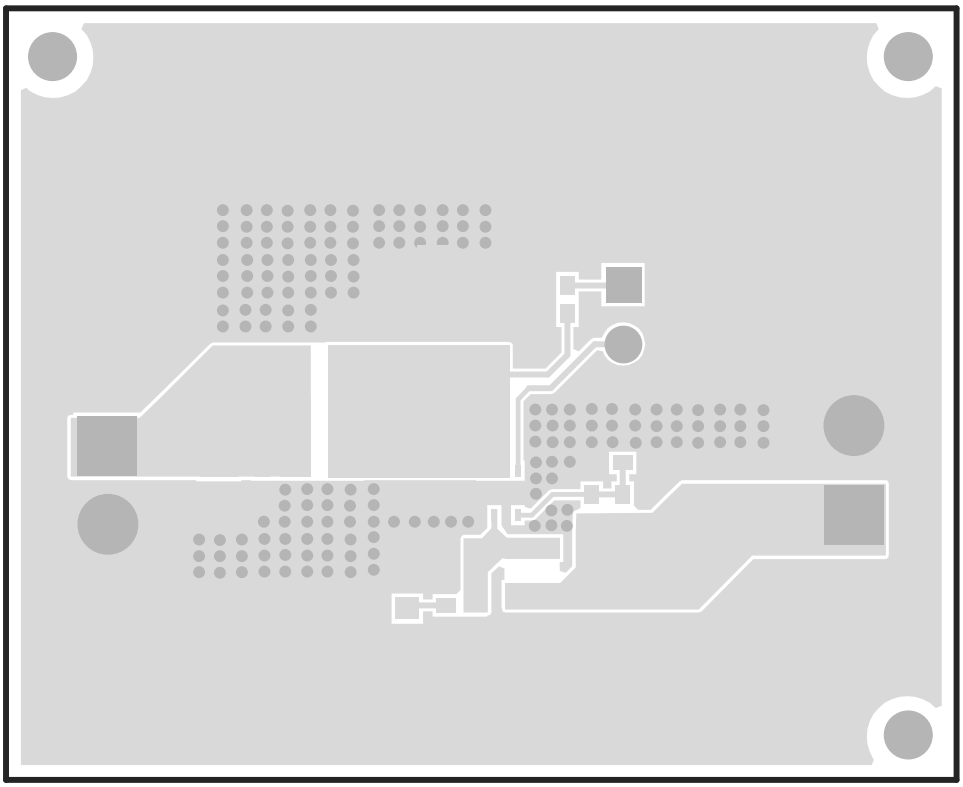

Figure 2. Top Layer Routing

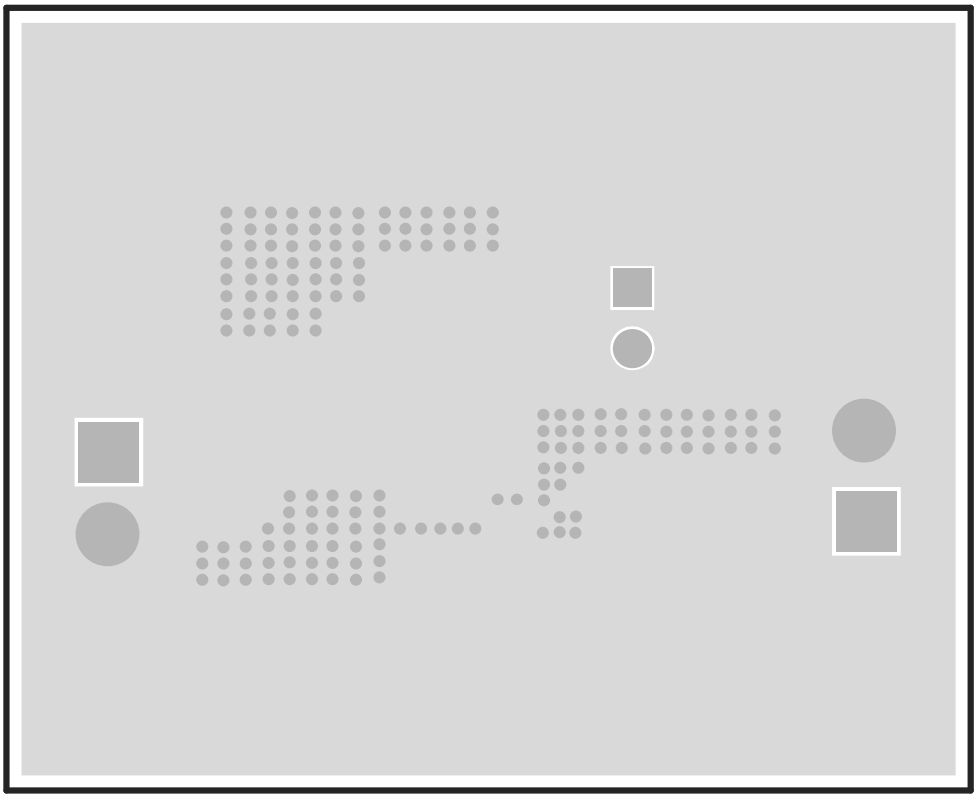

Figure 3. Bottom Layer (Ground Plane)

2 Description of Test Setup and Test Result

According to the CISPR25 test setup, the device under test (DUT) should be supplied from a 12-V car battery. Because the maximum input voltage of HVL119 is 5.5 V, a preregulator must be added to convert the battery voltage down to 5 V. In this case, the TPS54362BEVM was used which is an EVM design for good EMI performance based on the TPS54362-Q1 device (version TPS54362BQPWPRQ1). For more information on the TPS54362-Q1 device, see the device product folder (www.ti.com/product/TPS54362-Q1) and the test report, *Passing CISPR25 Radiated Emissions Using TPS54362B-Q1* (SLVA661).

The ambient radiation must be measured to show the performance of HVL119. The ambient radiation is measured for the complete test setup but with the device under test (DUT) disabled which results in the ambient radiation containing the background noise and the radiation from the preregulator. By subtracting the ambient radiation from the test result, the effect of HVL119 is obtained.

2.1 Setup Conditions

- DUT: HVL119, using TLV62065-Q1
  - Switching frequency: f_{SW} = 3 MHz
  - Input voltage: V_{IN} = 5 V
  - Output voltage: V_{OUT} = 1.8 V
  - Load current: I_{OUT} = 1.8 A (1-Ω resistive load)
- Separated with wire harness at a distance of 1.7 m from the input voltage
- CISPR25 LISNs placed between preregulator and wire harness
- Input voltage: preregulator TPS54362BEVM (5 V) supplied from a car battery
  - Switching frequency: f_{SW} = 500 kHz
  - Input voltage: V_{IN} = 12 V (Battery)
  - Output voltage: V_{OUT} = 5 V
- Wire harness and DUT placed on 50 mm of insulation with respect to test table

2.2 Photo of Test Setup and Result for Monopole

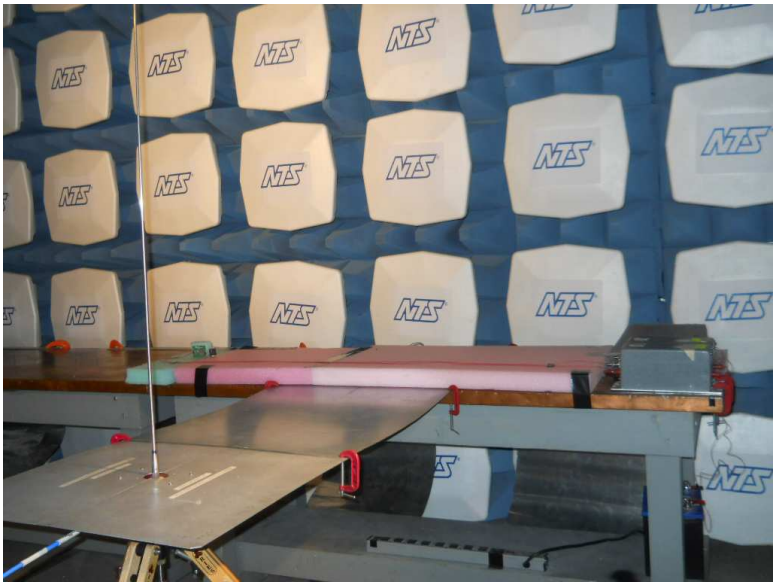

Figure 4. Monopole Setup

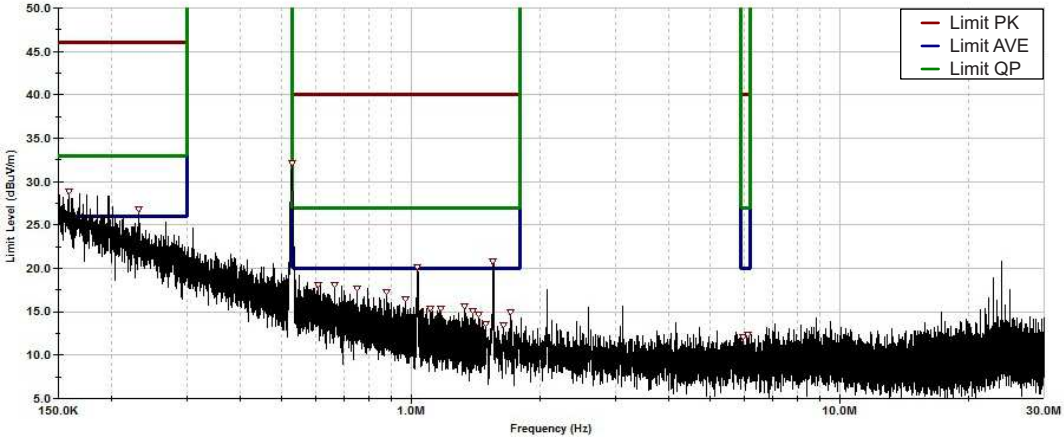

Figure 5. Monopole Ambient Radiation

Table 3. Monopole Ambient Radiation Test Data

Frequency	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency	Limit dBµV/m	Peaks dBµV/m	Margin dB
159.45 kHz	26	28.84	2.84		1.1763 MHz	20	15.4	-4.6
231.68 kHz	26	26.76	0.76		1.3345 MHz	20	15.66	-4.34
527.33 kHz	100	32.11	-67.89		1.3932 MHz	20	15.04	-4.96
609.17 kHz	20	18.07	-1.93		1.4436 MHz	20	14.74	-5.26
661.82 kHz	20	18.02	-1.98		1.4938 MHz	20	13.58	-6.42
749.74 kHz	20	17.71	-2.29		1.5574 MHz	20	20.76	0.76
875.12 kHz	20	17.26	-2.74		1.6401 MHz	20	13.42	-6.58
971.31 kHz	20	16.5	-3.5		1.7076 MHz	20	15	-5
1.0371 MHz	20	20.17	0.17		5.9651 MHz	20	12.09	-7.91
1.1093 MHz	20	15.37	-4.63		—	—	—	—

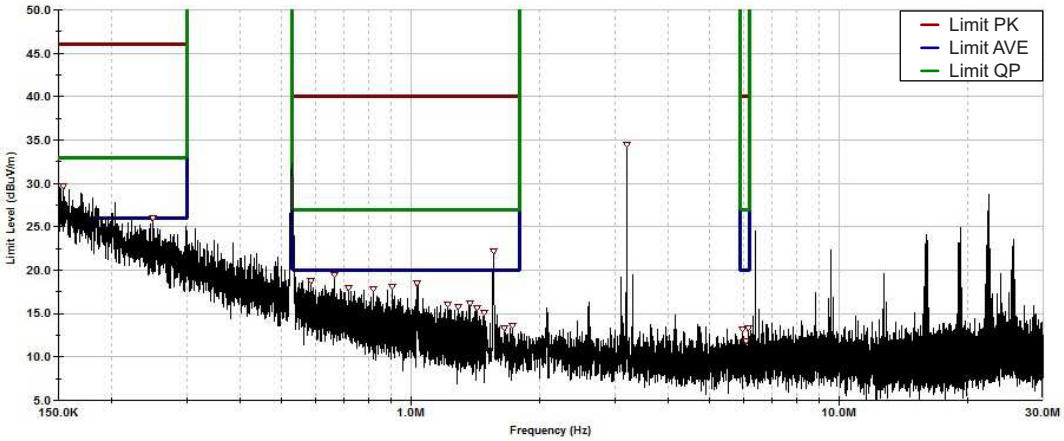

Figure 6. Monopole Result

Table 4. Monopole Test Data

Frequency	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency	Limit dBµV/m	Peaks dBµV/m	Margin dB
154.56 kHz[1]	26	29.69	3.69		1.3728 MHz	20	16.11	–3.89
250.07 kHz	26	25.94	–0.06		1.4293 MHz	20	15.64	–4.36
583.18 kHz	20	18.72	–1.28		1.4882 MHz	20	15.03	–4.97
661.82 kHz	20	19.47	–0.53		1.5624 MHz[2]	20	22.15	2.15
715.14 kHz	20	17.98	–2.02		1.6536 MHz	20	13.33	–6.67
817.58 kHz	20	17.75	–2.25		1.7329 MHz	20	13.62	–6.38
903.81 kHz	20	18.03	–1.97		3.1993 MHz	100	34.43	–65.57
1.0368 MHz	20	18.52	–1.48		5.9736 MHz	20	13.12	–6.88
1.2179 MHz	20	16.01	–3.99		6.0563 MHz	20	11.8	–8.2
1.2889 MHz	20	15.74	–4.26		—	—	—	—

(1) Subtracting the measured field strength at 154 kHz with the corresponding ambient radiation (27 dBµV/m) value results in 29.69 – 27 = 2.69 dBµV/m

(2) The peak at 1.5 MHz can be obtained in the ambient radiation. By subtracting the value ambient radiation the device passes this limit.

2.3 Photo of Test Setup and Result for Bicon Vertical

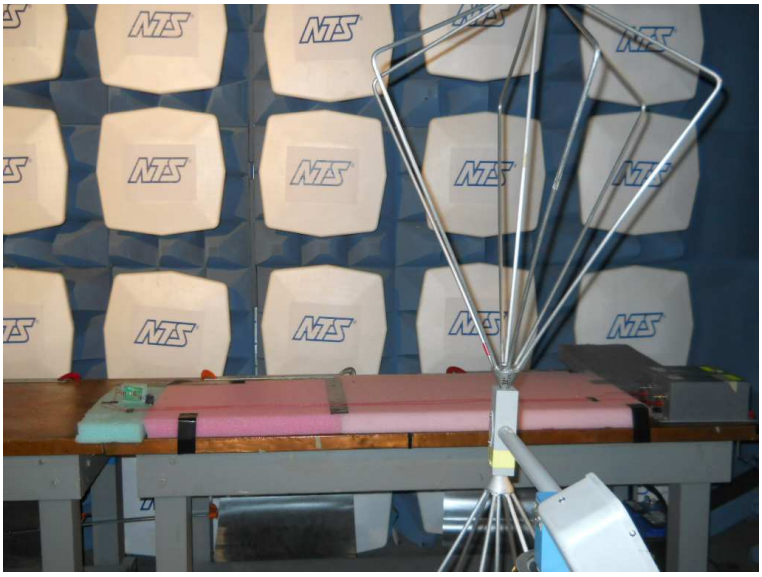

Figure 7. Bicon Vertical

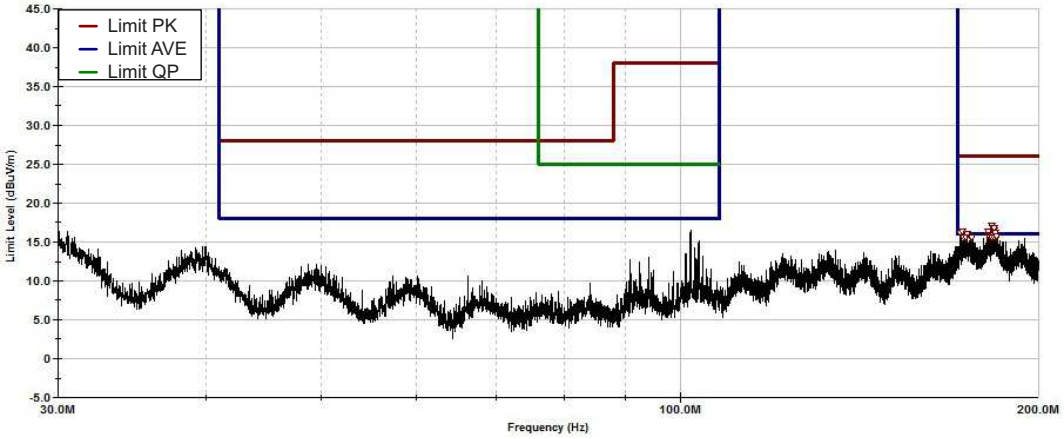

Figure 8. Bicon Vertical Ambient Radiation

Table 5. Bicon Vertical Ambient Radiation Data

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
171.865	16	16.15	0.15		182.681	16	15.83	–0.17
172.439	16	16.28	0.28		182.745	16	17.08	1.08
173.034	16	15.63	–0.37		182.809	16	15.64	–0.36
173.65	16	15.59	–0.41		183.106	16	15.87	–0.13
174.16	16	16.03	0.03		183.489	16	16.56	0.56
175.244	16	15.58	–0.42		183.637	16	15.65	–0.35
175.626	16	15.67	–0.33		183.765	16	16.76	0.76
181.279	16	15.88	–0.12		183.893	16	16.21	0.21
181.555	16	16.29	0.29		184.381	16	15.66	–0.34
181.938	16	15.79	–0.21		—	—	—	—

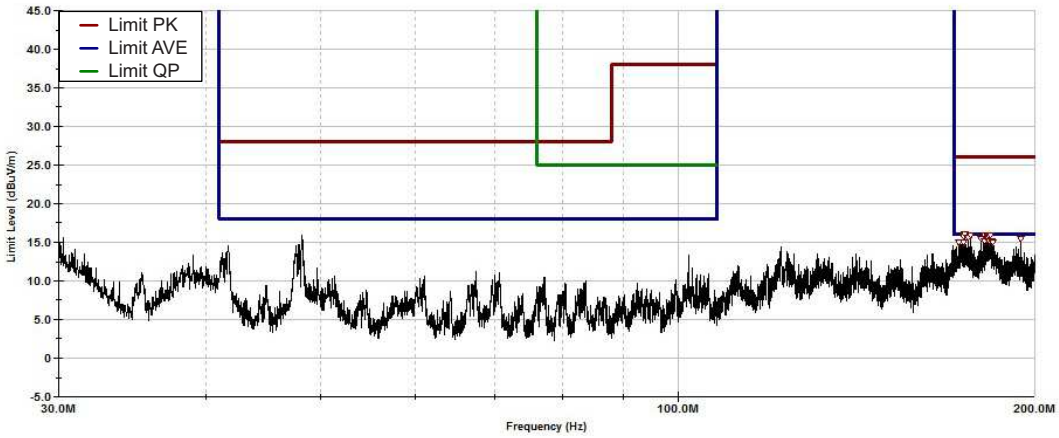

Figure 9. Bicon Vertical Result

Table 6. Bicon Vertical Test Data

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
172.843	16	14.97	–1.03		182.426	16	15.52	–0.48
174.181	16	15.06	–0.94		182.681	16	15.84	–0.16
174.33	16	15.7	–0.3		182.915	16	15.52	–0.48
174.67	16	15.99	–0.01		183.064	16	15.74	–0.26
175.945	16	15.66	–0.34		183.191	16	15.21	–0.79
176.54	16	15.97	–0.03		183.298	16	15.17	–0.83
180.089	16	15.38	–0.62		183.404	16	15.91	–0.09
181.385	16	15.14	–0.86		183.956	16	15.16	–0.84
181.47	16	15.86	–0.14		184.594	16	15.01	–0.99
182.193	16	15.96	–0.04		—	—	—	—

2.4 Photo of Test Setup and Result for Bicon Horizontal

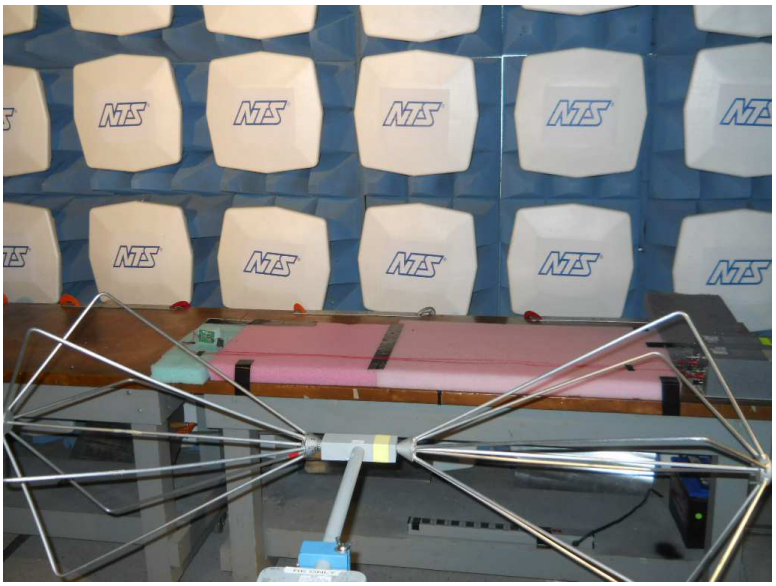

Figure 10. Bicon Horizontal

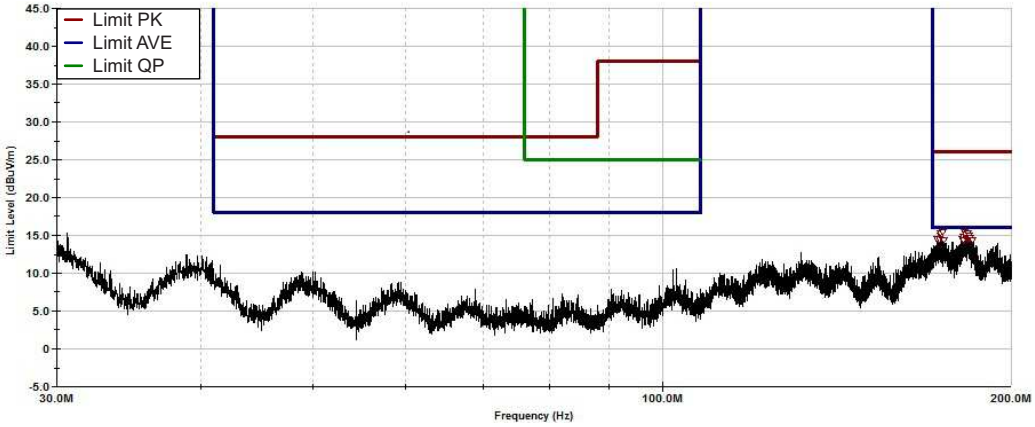

Figure 11. Bicon Horizontal Ambient Radiation

Table 7. Bicon Horizontal Ambient Radiation Data

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
172.524	16	14.48	–1.52		182.639	16	15.08	–0.92
173.331	16	14.47	–1.53		182.979	16	14.74	–1.26
173.671	16	15.03	–0.97		183.255	16	14.6	–1.4
173.905	16	15.26	–0.74		183.404	16	14.54	–1.46
174.606	16	15.4	–0.6		183.616	16	15.37	–0.63
174.968	16	14.44	–1.56		183.829	16	14.62	–1.38
181.343	16	14.5	–1.5		183.956	16	14.97	–1.03
181.852	16	14.82	–1.18		184.02	16	14.71	–1.29
182.044	16	14.39	–1.61		184.232	16	14.7	–1.3
182.32	16	15.48	–0.52		—	—	—	—

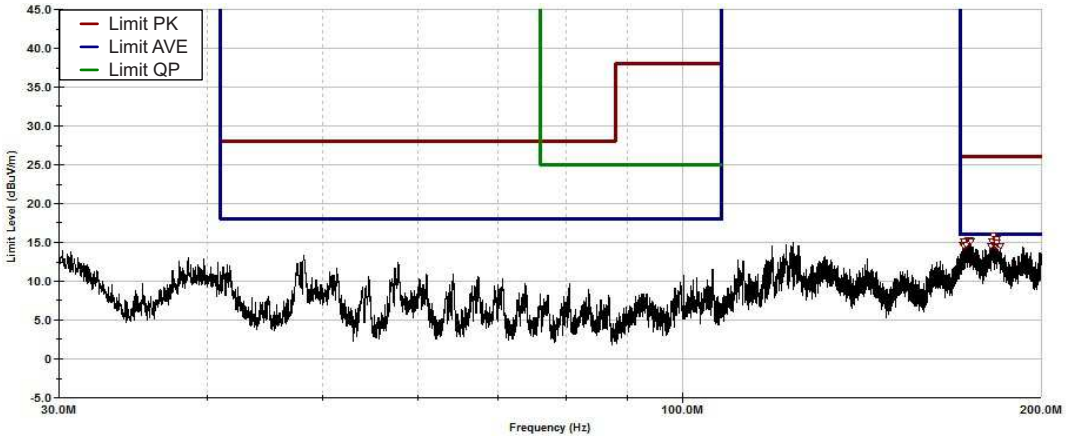

Figure 12. Bicon Horizontal Result

Table 8. Bicon Horizontal Test Data

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
171.971	16	14.74	–1.26		182.235	16	15.94	–0.06
172.184	16	14.6	–1.4		182.66	16	14.7	–1.3
172.248	16	15.17	–0.83		182.83	16	14.71	–1.29
173.076	16	14.74	–1.26		182.915	16	14.76	–1.24
174.011	16	15.25	–0.75		183.191	16	14.62	–1.38
174.224	16	14.98	–1.02		183.319	16	14.66	–1.34
174.394	16	15.22	–0.78		183.404	16	15.4	–0.6
174.564	16	15.19	–0.81		183.553	16	14.57	–1.43
181.47	16	14.52	–1.48		183.701	16	14.99	–1.01
181.831	16	15.09	–0.91		—	—	—	—

2.5 Photo of Test Setup and Result for Logarithmic Vertical

Figure 13. Logarithmic Vertical

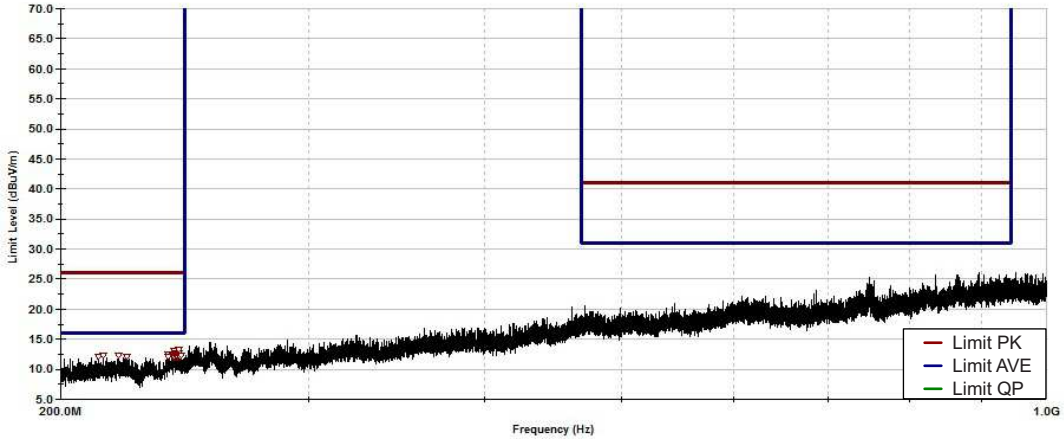

Figure 14. Logarithmic Vertical Ambient Radiation

Table 9. Logarithmic Vertical Ambient Radiation Data

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
213.1	16	12.09	–3.91		241.28	16	12.52	–3.48
214.65	16	12.27	–3.73		241.6	16	12.01	–3.99
219.8	16	12.27	–3.73		241.85	16	12.63	–3.37
223.18	16	12.14	–3.86		241.97	16	12.55	–3.45
238.32	16	12.56	–3.44		242.18	16	12.17	–3.83
238.75	16	12.14	–3.86		242.4	16	12.38	–3.62
240.43	16	12.21	–3.79		242.47	16	12.68	–3.32
240.68	16	13.08	–2.92		242.78	16	13.25	–2.75
240.8	16	12.11	–3.89		243.28	16	12.06	–3.94
241.22	16	12.19	–3.81		—	—	—	—

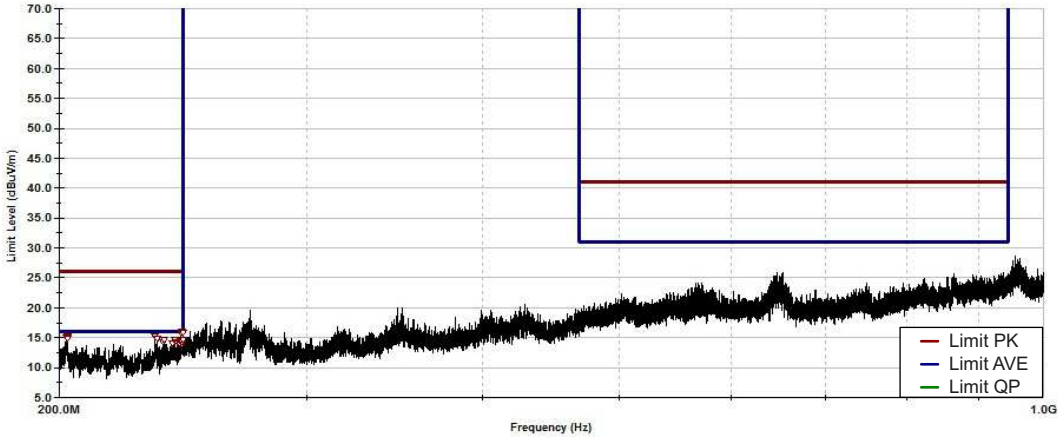

Figure 15. Logarithmic Vertical Ambient Result

Table 10. Logarithmic Vertical Test Result

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
202.32	16	14.94	–1.06		241.65	16	14.63	–1.37
202.75	16	15.27	–0.73		242.53	16	14.26	–1.74
202.85	16	15.09	–0.91		243.75	16	14.07	–1.93
202.95	16	14.86	–1.14		243.8	16	14.06	–1.94
234	16	15.24	–0.76		244.2	16	14.15	–1.85
235.03	16	14.75	–1.25		244.5	16	15.67	–0.33
237.35	16	14.25	–1.75		244.55	16	14.01	–1.99
237.43	16	14.73	–1.27		244.63	16	15.97	–0.03
240.93	16	14.08	–1.92		244.68	16	14.44	–1.56
241.22	16	12.19	–3.81		244.85	16	14.54	–1.46

2.6 Photo of Test Setup and Result for Logarithmic Horizontal

Figure 16. Logarithmic Horizontal

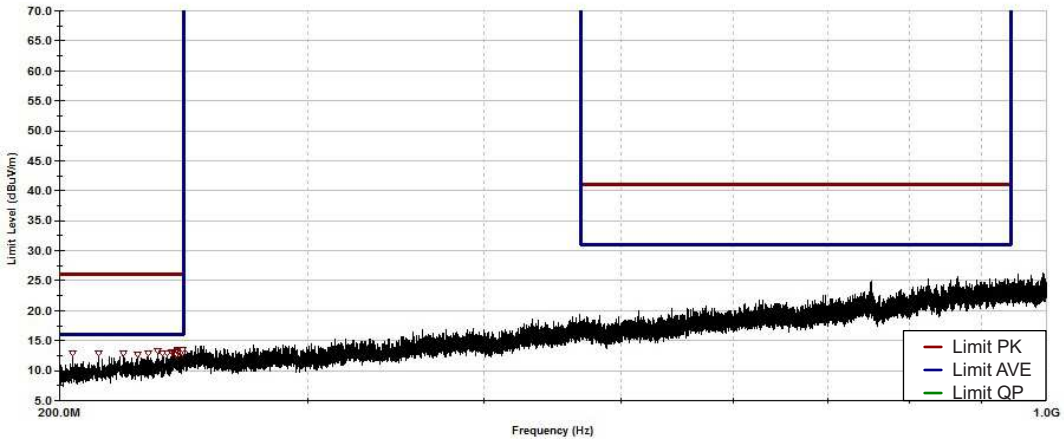

Figure 17. Logarithmic Horizontal Ambient Radiation

Table 11. Logarithmic Horizontal Ambient Radiation

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
204.63	16	12.91	–3.09		241.25	16	12.91	–3.09
213.18	16	12.79	–3.21		242	16	12.72	–3.28
222.18	16	12.84	–3.16		242.15	16	12.63	–3.37
227.4	16	12.58	–3.42		242.78	16	13.45	–2.55
231.15	16	12.94	–3.06		242.9	16	13.31	–2.69
234.78	16	13.17	–2.83		243.65	16	13.47	–2.53
236.85	16	12.87	–3.13		243.72	16	13.12	–2.88
238.63	16	12.77	–3.23		244.22	16	13.19	–2.81
240.43	16	13.07	–2.93		244.35	16	12.79	–3.21
240.47	16	13.06	–2.94		—	—	—	—

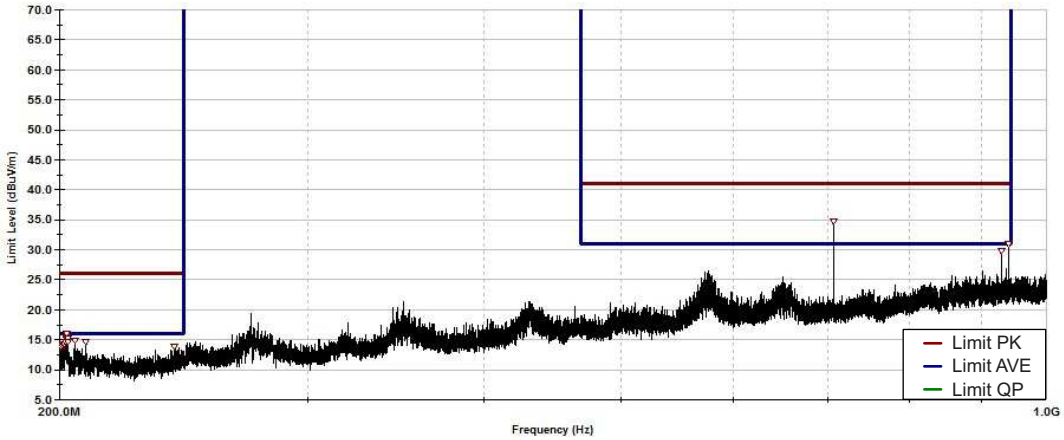

Figure 18. Logarithmic Horizontal Result

Table 12. Logarithmic Horizontal Test Result

Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB		Frequency MHz	Limit dBµV/m	Peaks dBµV/m	Margin dB
200	16	14.06	–1.94		202.55	16	15.2	–0.8
200.47	16	13.92	–2.08		202.6	16	15.93	–0.07
200.78	16	14.28	–1.72		202.78	16	15.28	–0.72
201	16	14.15	–1.85		202.82	16	14.62	–1.38
201.07	16	14.02	–1.98		205.38	16	14.85	–1.15
201.32	16	14.21	–1.79		208.68	16	14.62	–1.38
201.47	16	14.33	–1.67		241.2	16	13.9	–2.1
201.72	16	14.21	–1.79		707.5[(1)]	31	34.64	3.64
202.2	16	14.64	–1.36		929.65	31	29.77	–1.23
202.25	16	15.4	–0.6		—	—	—	—

(1) The ambient radiation value at this spike is 20 dBµV/m. By subtracting the ambient from the measured peak, 34.64 – 20 = 14.64 dBµV/m, the peak value becomes 15 dBµV/m below the limit.

3 Conclusion

In summary, this design proves that TLV62065-Q1 can be used to pass the CISPR25 Class 5 Radiated Emission test. The test result shows a spike at 707.5 MHz for the logarithmic horizontal test, although this spike is most likely caused by parasitic elements in the circuit.

With only a two layer board with a ground plane very close to the top routing layer, the loop inductance is well minimized which results in attenuating the high-frequency components and makes a DC-DC converter pass EMI/EMC CISPR25 class 5.

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