Motor Driver Series

REFMOT003-EVK-001 EMC Test Result Report

This document consists of the following contents.

Contents

1. Outline of the evaluation

1.1. Objectives

REFMOT003-EVK-001 is a reference design for Hall sensor driven three-phase brushless motor drivers.

REFMOT003-EVK-001 incorporates the EMC measures required for automotive market applications.

Evaluations have been done in accordance with the CISPR 25 standard, confirming the effectiveness of EMC countermeasures.

Measurement item

- CISPR 25 conducted and radiated noise test
- Measured in EMC measurement room

1.2. Evaluation target

REFMOT003-EVK-001 Reference Board

1.3. Evaluation items

Table 1. Evaluation Items

Evaluation Items	Frequency	antenna
Conducted noise measurement	150kHz to 108MHz	-
Radiated noise measurement	150kHz to 30MHz	vertical
	30MHz to 300MHz	horizontality / vertical
	300MHz to 1GHz	horizontality / vertical

1.4. Measuring instruments used

Table 2. List of measuring instruments

measuring instrument	manufacturer	Model Number	Serial Number
Power supply	KIKUSUI	PAN16-10A	DL000958
LISN（GND side）	NETZNACHBILDUNG	NNBN8125	81251638
LISN（VIN side）	NETZNACHBILDUNG	NNBM8125	81251639
spectrum analyzer *	SCHWARZBECK	ESU26	100165
antenna（150kHz-30MHz)	ETS-LINDGREN	3301C	211493
antenna（30MHz-300MHz)	ETS-LINDGREN	3110B	3376

1.5. Test environment

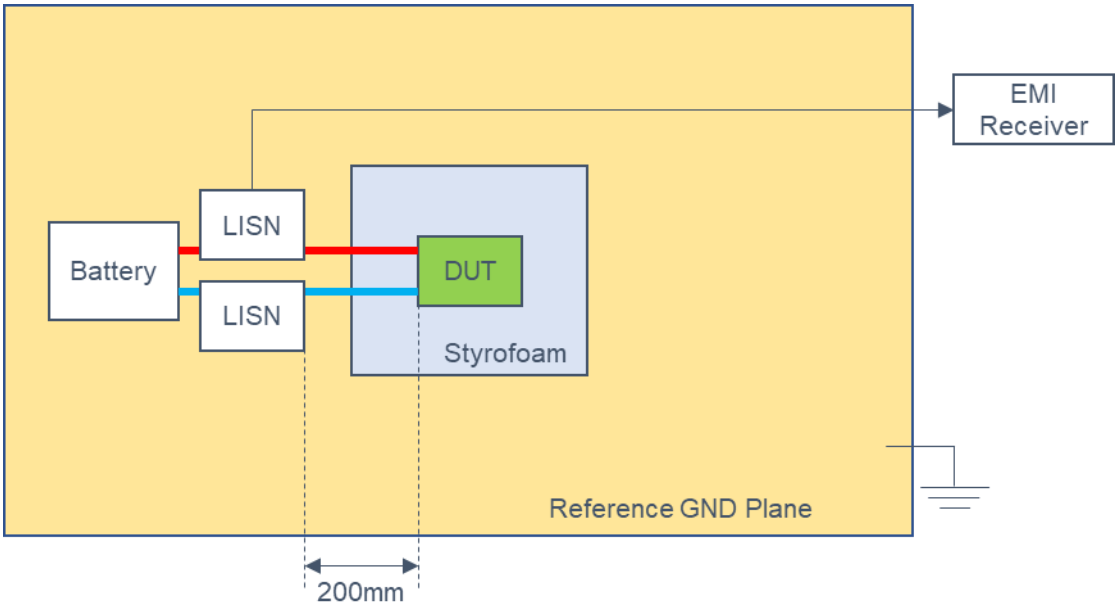


Figure 1. Conducted noise measurement system Top view

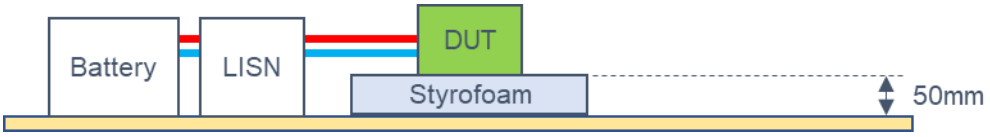


Figure 2. Conducted noise measurement system Side

LISN:Line Impedance Stabilization Network

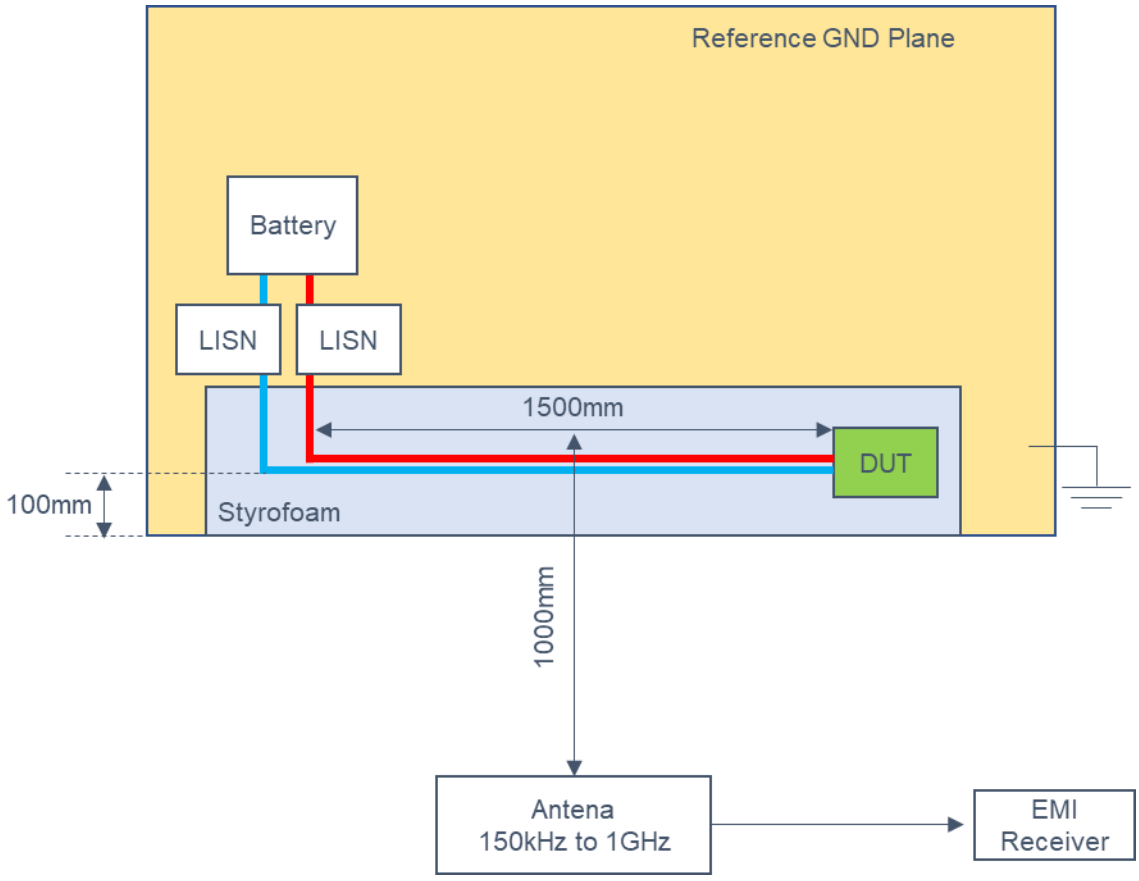


Figure 3. Radiated noise measurement Top view

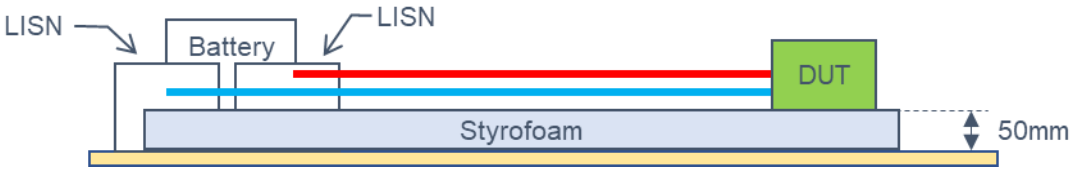


Figure 4. Radiated noise measurement Side view

1.6. Measurement Conditions

Table 3. Measurement conditions

Item	contents
Temperature Conditions	Room temperature 27℃
Input voltage condition	12V DC Power Supply
Load	Blower motor
Motor current	10Ap-p

1.7. Reference Design System Diagram / Schematic / Parts List

A system diagram of this reference design is shown in Figure 5.

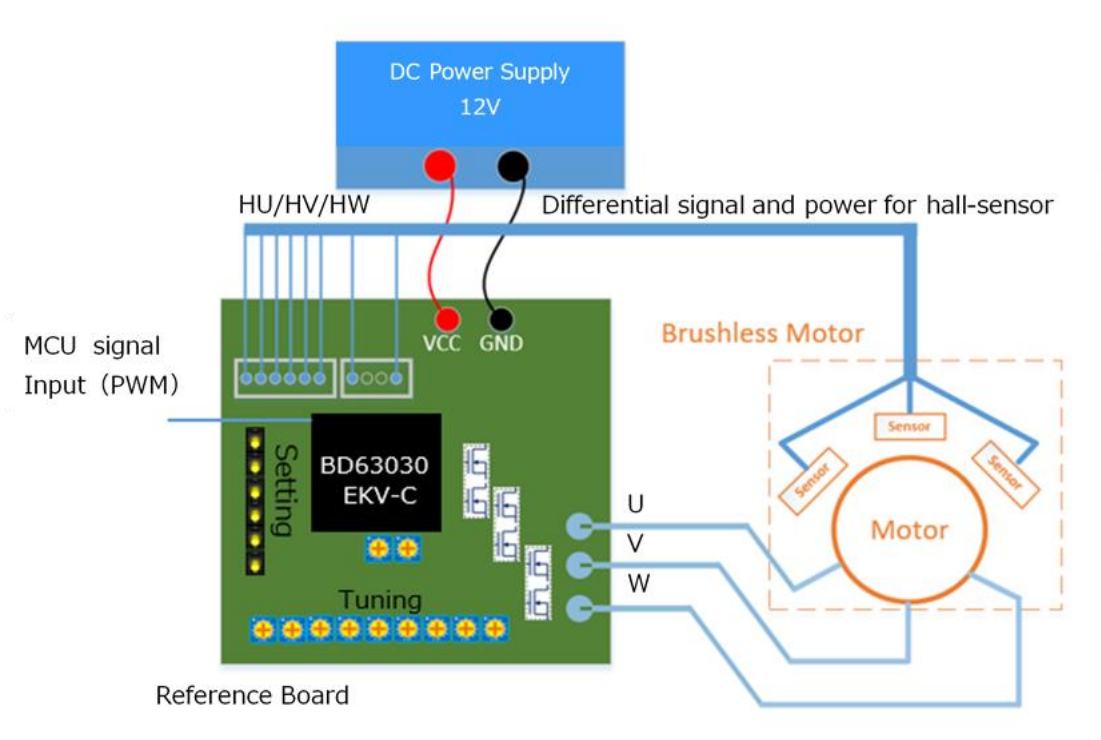


Figure 5. REFMOT003 Reference design

The schematic of the reference board REFMOT003-EVK-001 is shown in Figure 6.

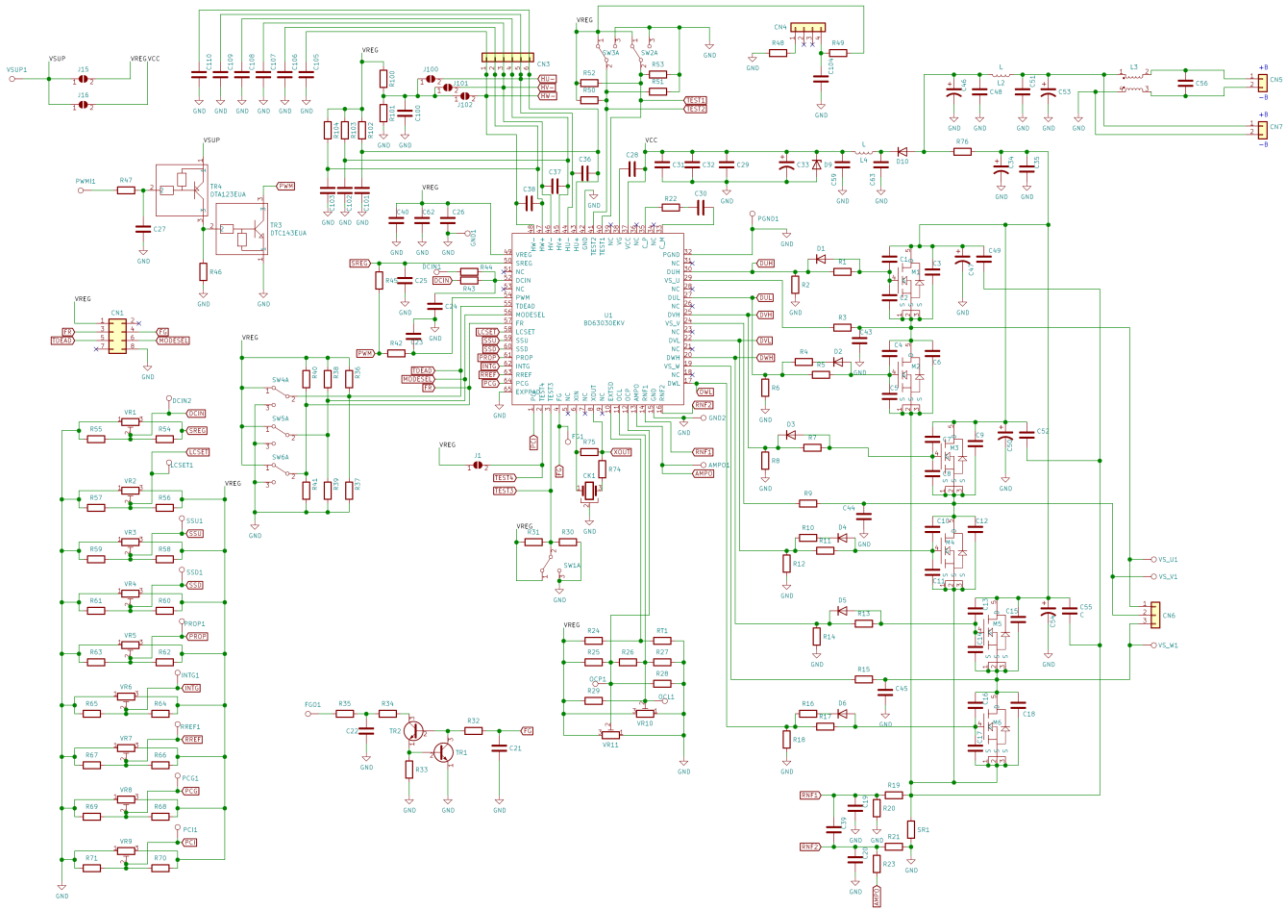


Figure 6. REFMOT003-EVK-001 Circuit

Table 4. Parts List

Designator	Type	Parts Value	Description	Product Name	Manufacturer	Footprint
-	EVALUATION BOARD	-	Board	Evaluation board	-	-
C104	Capacitor	0.1μF	50V,±10%	CGA2B3X7R1H104 K050BB	TDK	1005
C105,C106,C107,C108,C109,C110	Capacitor	4700pF	50V,±10%	CGA2B2X7R1H472 K050BE	TDK	1005
C19, C20, C24, C25, C27, C28, C29, C30, C36, C37, C38, C49, C52, C55	Capacitor	0.1μF	50V,±10%	CGA2B3X5R1H104 K050BB	TDK	1005
C22	Capacitor	22000pF	50V,±10%	CGA2B3X7R1H223 K050BB	TDK	1005
C23, C39	Capacitor	100pF	50V,±10%	CGA2B2C0G1H101 J050BA	TDK	1005
C26,C31	Capacitor	470nF	50V,±10%	CGA3E3X7R1H474 K080AB	TDK	1608
C33	Aluminum Electrolytic Capacitor	100μF	50V,±10%	UBT1H101MPD8	Nichicon	φD×L(mm):10x20
C34,C46,C47,C50,C54	Aluminum Electrolytic Capacitor	330μF	50V,±10%	UBT1H331MHD8	Nichicon	φD×L(mm):12.5x20
C40	Capacitor	1μF	16V	CGA3E1X7R1C105 K080AC	TDK	1608
C48,C51,C56	Capacitor	0.1μF	50V,±10%	CGA2B3X7R1H104 K050BB	TDK	1005
C53	Aluminum Electrolytic Capacitor	1000μF	50V,±10%	UBT1H102MHD8	Nichicon	16x31.5
CK1	OSCILLATOR	10MHz	±0.5%,40Ω,33pF	CSTNE10M0G55A	Murata	CSTCE_G_A
CN1	Header Connector	-	-	HDR 2X4	-	HDR(2X4)
CN3	Header Connector	-	-	HDR 1X6	-	HDR(1X6)
CN4	Header Connector	-	-	HDR 1X4	-	HDR(1X4)
CN5, CN7	Connector	-	-	OSTT7022150	ON-SHORE TECHNOLOGY	-
CN6	Connector	-	-	OSTT7032150	ON-SHORE TECHNOLOGY	-
D1, D2, D3, D4, D5, D6	Diode	-	-	RRE01VM4SFHTE-17	ROHM	D_3216
D10	Diode	-	-	RR1LAM4STF	ROHM	D1F60
D9	Zenner Diode	30V	-	KDZVTF30B	ROHM	D_MCR50WLEAD
DCIN1	CHECK PIN	-	Test Pin, Through Hole	LC-2-G Yellow	-	TP/1.6/2.3
DCIN2,LCSET1,SSU1,SSD1,PROP1,INTG1 RREF1,PCG1,PCI1,OCP1,OCL1	CHECK PIN	-	Test Pin, Through Hole	LC-2-G Yellow	-	TP/1.6/2.3
FGO1、VS_U1、VS_V1、VS_W1	CHECK PIN	-	Test Pin, Through Hole	LC-2-G White	-	TP/1.6/2.3
J1, J16	Jumper	-	-	-	-	SS/1.5X1.5/0.5
J15	Jumper	-	-	-	-	SS/1.5X1.5/0.5
L2	Inductor	1.3μH	±20%	XAL1350-132MED	Coilcraft	14mm2
L3	Common mode choke	500Ω@10MHz	Common mode choke	PLT10HH501100PN	Murata	12.9x6.6
L4		Short				1608
M1, M2, M3, M4, M5, M6	Nch MOSFET	BVDSS 40V / Ron(Max)1.4Ω Ciss 4460pF		Under development	ROHM	MOSFET(5X6)
PWMI1	CHECK PIN	-	Test Pin, Through Hole	LC-2-G Yellow	-	TP/1.6/2.3
R1, R7, R13	Resistor	470Ω	50V,±1%	MCR03EZPFX2400	ROHM	1608
R19, R21	Resistor	2.2kΩ	50V,±1%	MCR01MZPF2201	ROHM	1005
R2, R8, R14, R20, R23, R42, R46	Resistor	47kΩ	50V,±1%	MCR01MZPF4702	ROHM	1005

R22	Resistor	10Ω	50V,±1%	MCR01MZPF10R0	ROHM	1005
R24	Resistor	1.4kΩ	50V,±1%	MCR01MZPF1401	ROHM	1005
R3, R9, R15	Resistor	24Ω	50V,±1%	MCR03EZPFX24R0	ROHM	1608
R33	Resistor	75Ω	50V,±1%	MCR01MZPF75R0	ROHM	1005
R34, R43, R44		Short				1005
R35	Resistor	100Ω	50V,±1%	MCR01MZPF1000	ROHM	1005
R4, R10, R16	Resistor	51Ω	50V,±1%	MCR03EZPFX51R0	ROHM	1608
R47	Resistor	2.4kΩ	50V,±1%	MCR01MZPF2401	ROHM	1005
R48, R49, R74	Resistor	150Ω	50V,±1%	MCR01MZPF1500	ROHM	1005
R5, R11, R17	Resistor	270Ω	50V,±1%	MCR03EZPFX2700	ROHM	1608
R6, R12, R18, R32, R45	Resistor	10kΩ	50V,±1%	MCR01MZPF1002	ROHM	1005
R75	Resistor	1MΩ	50V,±1%	MCR01MZPF1004	ROHM	1005
R76	-	short		-	-	JUMPER(B)
RT1	NTC THERMISTORS	100kΩ	Thermistor	NTCG164KF104FTDS	TDK	1608
SR1	Resistor	1mΩ/8W	Shunt Resistor	PSR400ITQFH1L00	ROHM	PSR400
SW1, SW2, SW3,SW4, SW5, SW6	3 state switch	-	Switch	FT 1E-2M-Z	NIDEC COPAL	SW_FT1E-2M-Z
TR1, TR2	SILICON TRANSISTOR	-	NPN Transistor	2SC4081U3T106R	ROHM	TR_UMT3_SC-70_SOT-323
TR3	SILICON TRANSISTORS	-	NPN Digital Transistor	DTC143EU3HZGT106	ROHM	TR_UMT3_SC-70_SOT-323
TR4	SILICON TRANSISTORS	-	PNP Digital Transistor	DTA123EU3HZGT106	ROHM	TR_UMT3_SC-70_SOT-323
U1	INTEGRATED CIRCUITS	-	3 Phase Motor Driver	BD63030EKV-C	ROHM	TQFP-64V
VR1, VR2, VR3, VR4, VR5, VR6, VR7, VR8, VR9, VR10, VR11	Resistor	50kΩ	Variable Resistor	CT-6EP 50k Ohm	NIDEC COPAL	CT-6EP
VSUP1	CHECK PIN	-	Test Pin, Through Hole	LC-2-G Red	-	TP/1.6/2.3

1.8. Board Photograph

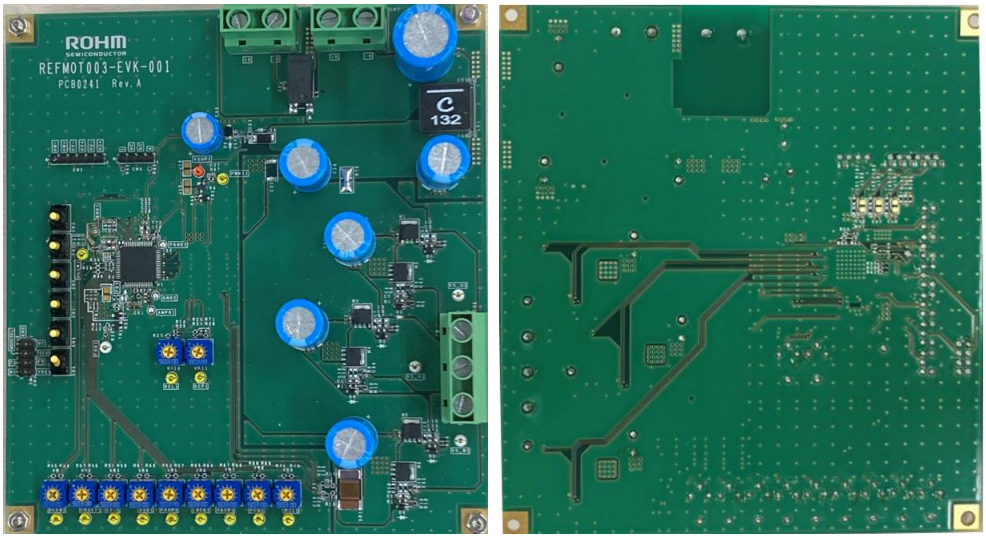


Figure 7. Reference Design Substrate

1.9. Reference Board Pattern

The board configuration of the reference design is shown in Table 5.

Layout pattern is shown.

Table 5. Reference Design Board Configuration

Material	FR-4
Board Thickness	1.6mm
Copper Thickness	Top/Bottom layer 2oz Inner layer 1oz
Number of Layers	4
Board Size	133mm x 145mm
Minimum Copper Width	0.15mm
Minimum Air Gap	0.15mm
Minimum Hole Size	0.3mm

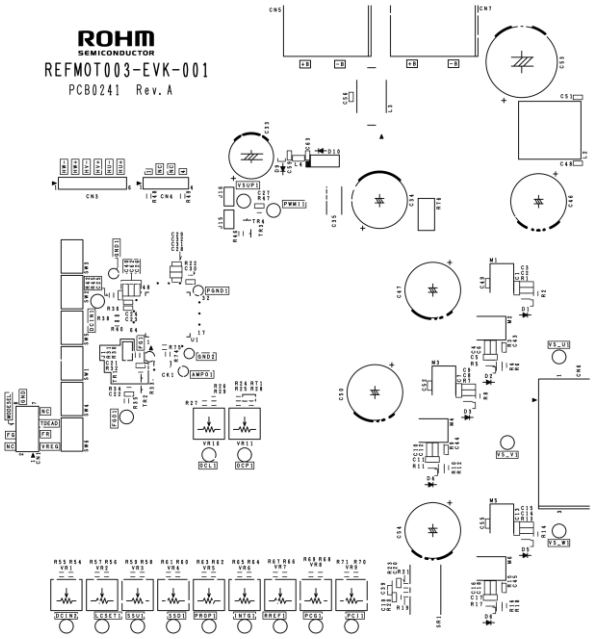


Figure 8. TOP SILK

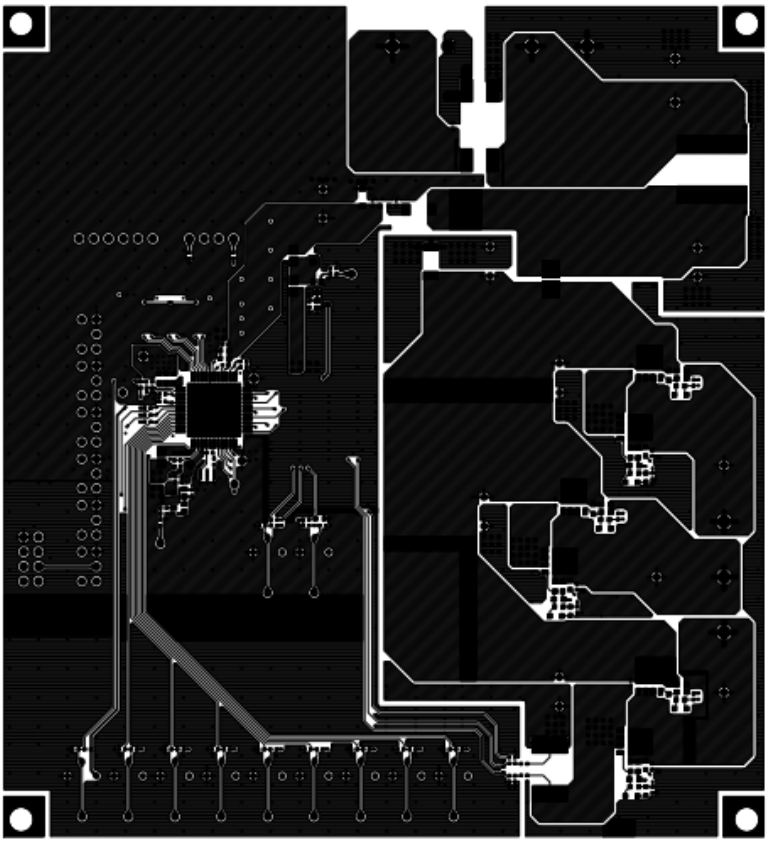


Figure 9. TOP metal

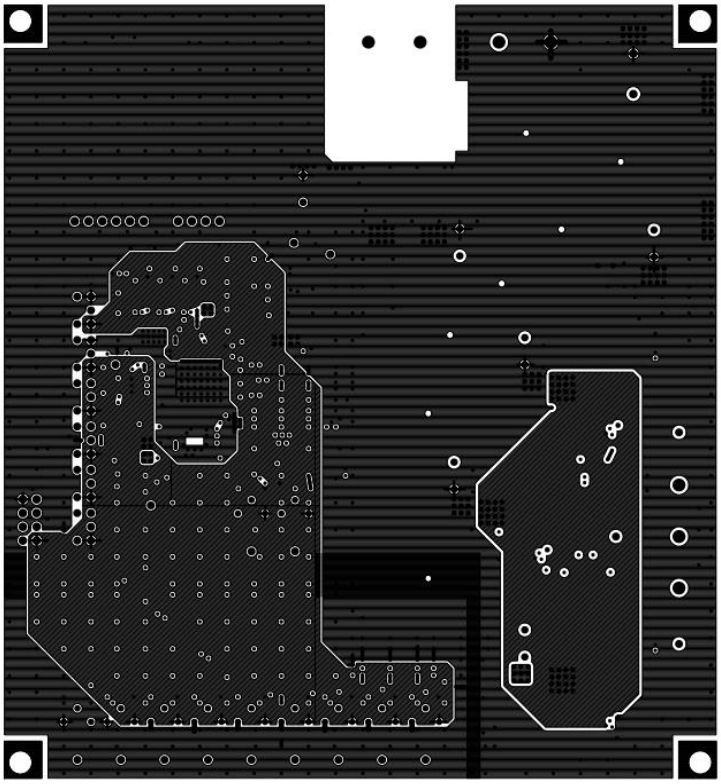


Figure 10. Inner layer 2

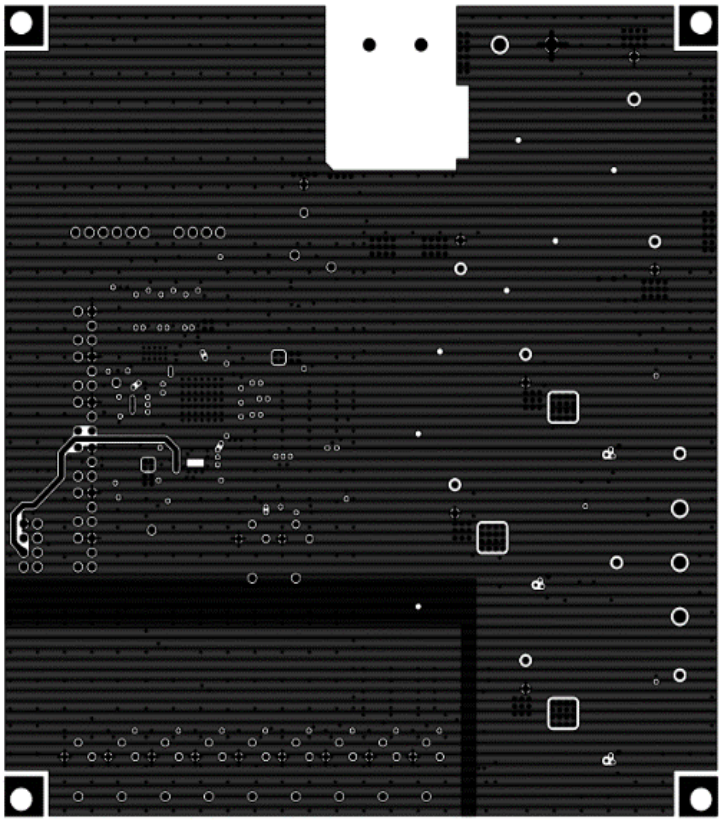


Figure 11. Inner layer 3

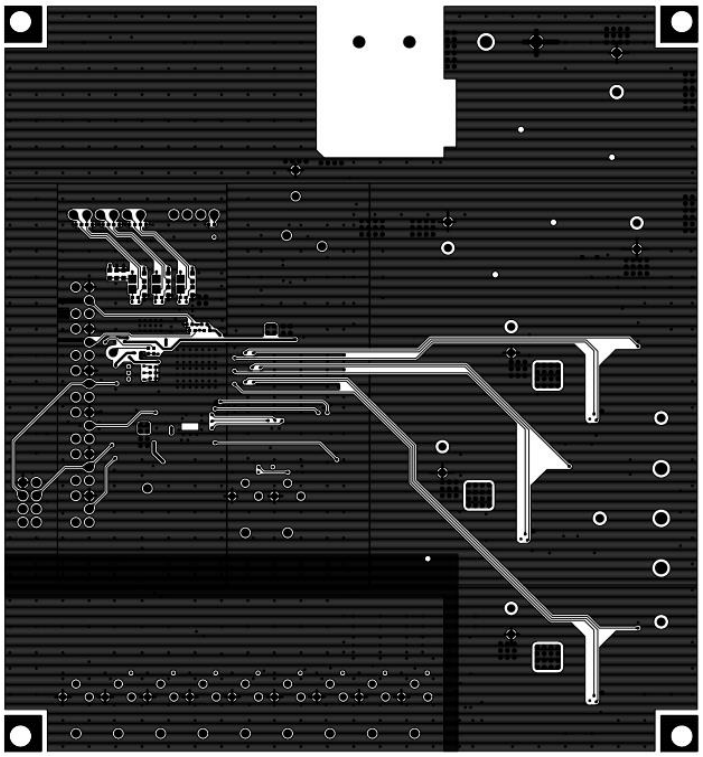


Figure 12 Bottom metal

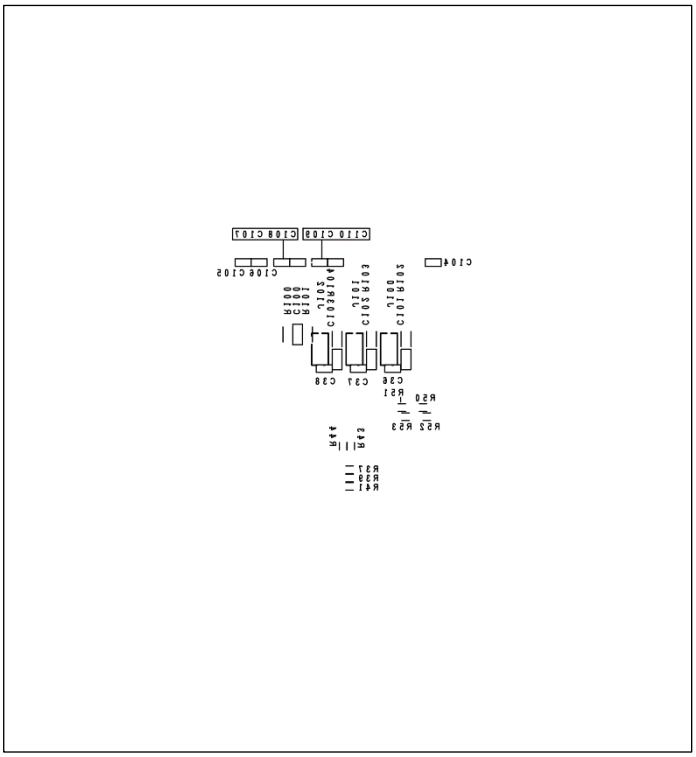


Figure 13. Bottom SILK

2. Evaluation Results

2.1. Conducted noise measurement

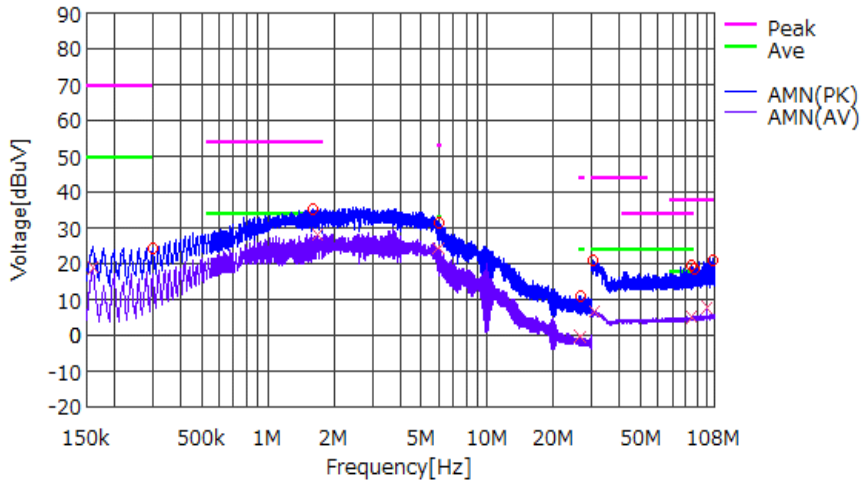


Figure 14. measurement results (waveform of common mode filter 500Ω)

Table 5. measurement results (waveform of common mode filter 500Ω)

Band ID	Frequency [MHz]	Measuring plane	Result PK	Result AV	Result QP	Limit PK	Limit AV	Limit QP	Margin PK [dB]	Margin AV [dB]	Margin QP [dB]	Judgment
LW	0.160	AMN	---	18.95	---	---	50.0	---	---	31.05	---	OK
LW	0.300	AMN	24.30	---	---	70.0	---	---	45.70	---	---	OK
MW	1.615	AMN	35.11	---	---	54.0	---	---	18.89	---	---	OK
MW	1.695	AMN	---	28.09	---	---	34.0	---	---	5.91	---	OK
SW	5.995	AMN	31.23	---	---	53.0	---	---	21.77	---	---	OK
SW	5.995	AMN	---	24.22	---	---	33.0	---	---	8.78	---	OK
FM	99.600	AMN	---	7.84	---	---	18.0	---	---	10.16	---	OK
FM	106.600	AMN	21.01	---	---	38.0	---	---	16.99	---	---	OK
TV I	85.650	AMN	---	5.07	---	---	24.0	---	---	18.93	---	OK
TV I	87.200	AMN	18.74	---	---	34.0	---	---	15.26	---	---	OK
CB	26.510	AMN	---	-0.32	---	---	24.0	---	---	24.32	---	OK
CB	26.590	AMN	11.06	---	---	44.0	---	---	32.94	---	---	OK
VHF	30.500	AMN	21.05	---	---	44.0	---	---	22.95	---	---	OK
VHF	30.950	AMN	---	6.72	---	---	24.0	---	---	17.28	---	OK
VHF	84.950	AMN	19.33	---	---	38.0	---	---	18.67	---	---	OK
VHF	85.300	AMN	---	5.01	---	---	18.0	---	---	12.99	---	OK

(Note 1) The pink line shows the Peak limit of CISPR 25 Class 5.

(Note 2) The green line shows the average limit value of CISPR 25 Class 5.

2.2. Radiated noise measurement

2.2.1. 150kHz to 30MHz

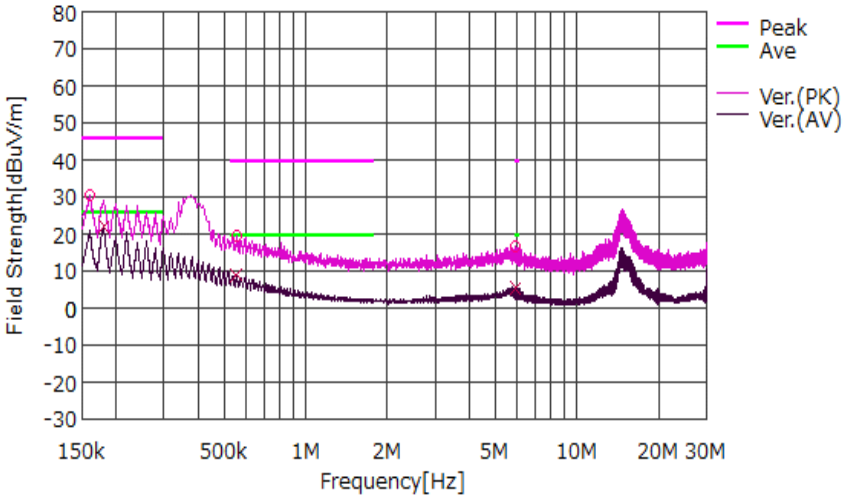


Figure15. Measurement results (150kHz to 30MHz)

Table 6. Measurement results (150kHz to 30MHz)

Band ID	Frequency	Measuring plane	Result			Limit ł			Margin			Judgment
			PK	AV	QP	PK	AV	QP	PK	AV	QP	
	[MHz]								[dB]	[dB]	[dB]	
LW	0.160	Ver.	28.87	---	---	46.0	---	---	17.13	---	---	OK
LW	0.180	Ver.	---	21.47	---	---	26.0	---	---	4.53	---	OK
MW	0.555	Ver.	---	9.23	---	---	20.0	---	---	10.77	---	OK
MW	0.595	Ver.	18.78	---	---	40.0	---	---	21.22	---	---	OK
SW	6.045	Ver.	15.00	---	---	40.0	---	---	25.00	---	---	OK
SW	6.125	Ver.	---	4.62	---	---	20.0	---	---	15.38	---	OK

(Note 1) The pink line shows the Peak limit of CISPR 25 Class 5.

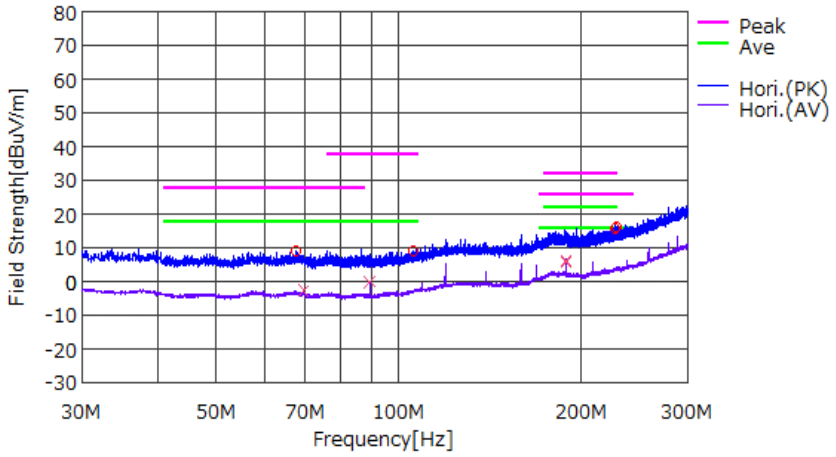
(Note 2) The green line shows the average limit value of CISPR 25 Class 5.

(Note 3) Motor and wiring are shielded.

2.2.2. 30MHz to 300MHz

Antenna

Horizontal



Antenna

Vertical

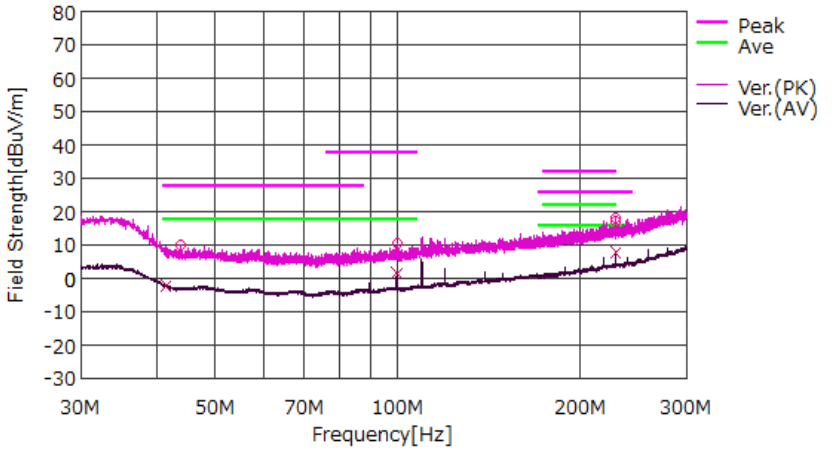


Figure 16. Measurement results (30MHz to 300MHz)

Table 7. Measurement results (30MHz to 300MHz)

Band ID	Frequency	Measuring plane	Result			Limit ł			Margin			Judgment
			PK	AV	QP	PK	AV	QP	PK	AV	QP	
	[MHz]								[dB]	[dB]	[dB]	
FM	89.500	Hori.	---	-0.15	---	---	18.0	---	---	18.15	---	OK
FM	99.450	Ver.	---	2.54	---	---	18.0	---	---	15.46	---	OK
FM	99.450	Ver.	11.32	---	---	38.0	---	---	26.68	---	---	OK
FM	105.800	Hori.	9.18	---	---	38.0	---	---	28.82	---	---	OK
TV I	46.100	Ver.	9.68	---	---	28.0	---	---	18.32	---	---	OK
TV I	46.800	Ver.	---	-2.37	---	---	18.0	---	---	20.37	---	OK
TV I	67.450	Hori.	9.19	---	---	28.0	---	---	18.81	---	---	OK
TV I	69.600	Hori.	---	-2.75	---	---	18.0	---	---	20.75	---	OK
TV III	188.950	Hori.	---	5.75	---	---	22.0	---	---	16.25	---	OK
TV III	227.750	Hori.	15.73	---	---	32.0	---	---	16.27	---	---	OK
TV III	228.700	Ver.	---	10.42	---	---	22.0	---	---	11.58	---	OK
TV III	228.700	Ver.	19.79	---	---	32.0	---	---	12.21	---	---	OK
DAB III	228.500	Hori.	16.19	---	---	26.0	---	---	9.81	---	---	OK
DAB III	219.200	Ver.	20.32	---	---	26.0	---	---	5.68	---	---	OK
DAB III	188.950	Hori.	---	6.24	---	---	16.0	---	---	9.76	---	OK
DAB III	228.750	Ver.	---	10.13	---	---	16.0	---	---	5.87	---	OK

(Note 1) The pink line shows the Peak limit of CISPR 25 Class 5.

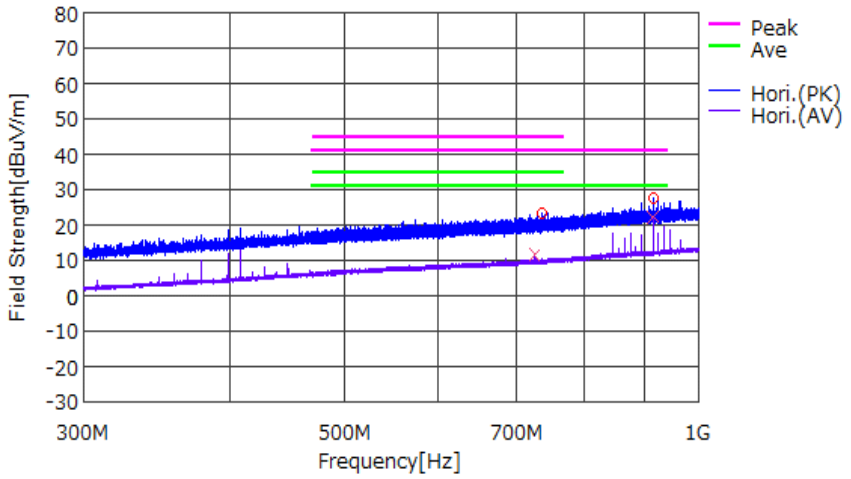
(Note 2) The green line shows the average limit value of CISPR 25 Class 5.

(Note 3) Motor and wiring are shielded.

2.2.3. 300MHz to 1GHz

Antenna

Horizontal



Antenna

Vertical

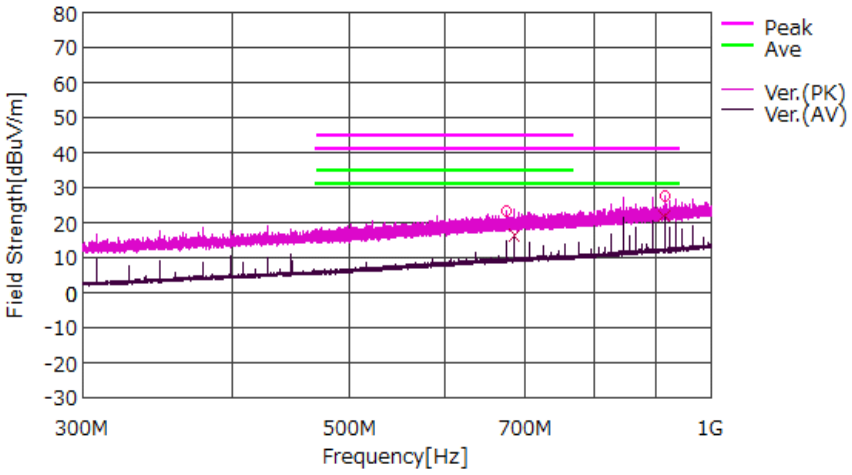


Figure 77. Measurement results (300MHz to 1GHz)

Table 8. Measurement results (300MHz to 1GHz)

Band ID	Frequency [MHz]	Measuring plane	Result PK	Result AV	Result QP	Limit PK	Limit AV	Limit QP	Margin PK [dB]	Margin AV [dB]	Margin QP [dB]	Judgment
TV IV	914.850	Hori.	---	22.30	---	---	31.0	---	---	8.70	---	OK
TV IV	914.850	Ver.	---	21.87	---	---	31.0	---	---	9.13	---	OK
TV IV	914.850	Hori.	27.74	---	---	41.0	---	---	13.26	---	---	OK
TV IV	914.900	Ver.	27.62	---	---	41.0	---	---	13.38	---	---	OK
DTTV	676.200	Ver.	23.29	---	---	45.0	---	---	21.71	---	---	OK
DTTV	686.150	Ver.	---	16.30	---	---	35.0	---	---	18.70	---	OK
DTTV	725.950	Hori.	---	11.54	---	---	35.0	---	---	23.46	---	OK
DTTV	735.350	Hori.	23.37	---	---	45.0	---	---	21.63	---	---	OK

(Note 1) The pink line shows the Peak limit of CISPR 25 Class 5.

(Note 2) The green line shows the average limit value of CISPR 25 Class 5.

(Note 3) Motor and wiring are shielded.

2.3. Summary

REFMOT003-EVK-001 EMC test results for both conducted noise / radiated noise were found to pass the specified values.

This test result report was conducted in our facilities using the reference board REFMOT003-EVK-001 and does not guarantee the performance under the customer's environment. Please note that it is provided as reference data.

Important Notes on the Use of Reference Designs

1) The contents of this document are subject to change without notice for the purpose of improvement.
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