System Reference series for Automotive application

REFRPT001-EVK-001 Application Note

This document provides measurement test report of the REFRPT001-EVK-001 board, which includes electrical characteristics, EMC noise and thermal measurement results. The REFRPT001-EVK-001 is a board included in power tree solution reference design named as REFRPT001 developed for infotainment devices such as vehicle clusters and center information displays, as well as for ADAS ECUs. The power system that can support functional safety is integrated on a single board, realizing an optimal configuration as a power tree. It has good EMC performance that meets CISPR25 Class 5 test standard even when all power supplies are operating. Heat dissipation of each device is reduced by distributing high-efficiency DCDC. In addition, two voltage monitoring ICs with self-diagnosis functions can monitor the output of all systems, which contributes to a higher level of functional safety.

This document consists of following chapters.

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System Block Diagram

System Block Diagram of REFRPT001-EVK-001 is shown below.

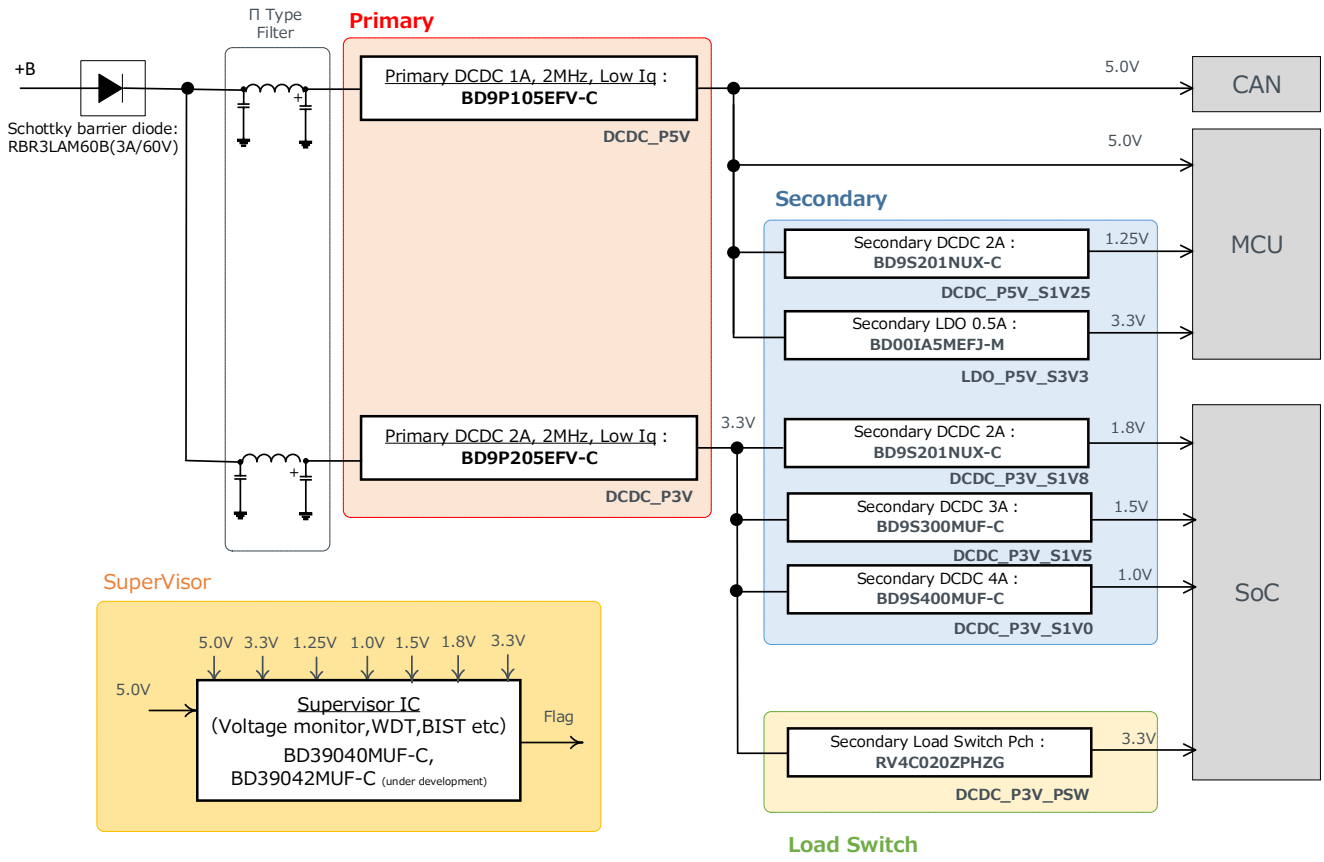

Figure 1 Block Diagram of REFRPT001-EVK-001

In this document, to distinguish between multiple products mounted on a board, the following symbol names are used here in after.

Table 1 Symbol name of products mounted on REFRPT001-EVK-001

Symbol Name	Product Name	Input Voltage (typ) [V]	Output Voltage (typ) [V]
DCDC_P5V	BD9P105EFV-C	12.0	5.0
DCDC_P5V_S1V25	BD9S201NUX-C	5.0	1.3
LDO_P5V_S3V3	BD00IA5MEFJ-M	5.0	3.3
DCDC_P3V	BD9P205EFV-C	12.0	3.3
DCDC_P3V_S1V0	BD9S400MUF-C	3.3	1.0
DCDC_P3V_S1V5	BD9S300MUF-C	3.3	1.5
DCDC_P3V_S1V8	BD9S201NUX-C	3.3	1.8
DCDC_P3V_PSW	RV4C20ZPHZG	3.3	3.3

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Operating Conditions

Operating condition of REFRPT001-EVK-001 is shown in Table 2

Table 2 Operating condition of REFRPT001-EVK-001

Parameter	Symbol in power tree	Limit			Unit	Conditions
		Min	Typ	Max		
Supply Voltage	+B	9.0	12.0	16.0	V	Break down Voltage 42V
Output Current*	DCDC_P5V	-	-	1.0	A	Vout 5.0V (typ), When operating alone
	DCDC_P5V_S1V25	-	-	1.25	A	Vout 1.25V (typ)
	LDO_P5V_S3V3	-	-	0.2	A	Vout 3.3V (typ)
	DCDC_P3V	-	-	2.0	A	Vout 3.3V (typ), When operating alone
	DCDC_P3V_S1V0	-	-	1.5	A	Vout 1.0V (typ)
	DCDC_P3V_S1V5	-	-	1.0	A	Vout 1.5V (typ)
	DCDC_P3V_S1V8	-	-	0.5	A	Vout 1.8V (typ)
	DCDC_P3V_PSW	-	-	0.15	A	Vout 3.3V (typ)

*Output current specification with consideration of heat generated by the current load of each power supply IC

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List of Evaluation items

List of evaluation items of REFRPT001-EVK-001 is as shown in Table 3 below. For more detail specification of each power supply ICs, please refer to each datasheet.

Table 3 List of Evaluation items

Chapter No.	Items	X-axis	Y-axis	Conditions
1.1	Output ripple waveform	Time	Output voltage	
1.2	Conversion efficiency	Output current	Efficiency	VIN=12V
1.3	Load regulation	Output current	Output voltage	VIN=12V
1.4	Line regulation	Input voltage	Output voltage	VIN=8 to 18V
1.5	Shutdown current	Input voltage	Input current	VIN=1 to 18V
1.6	Load responses	Output current	Output voltage	VIN=12V
1.7	Phase margin	Frequency	Gain, Phase	VIN=12V
1.8	Start-up waveform	Time	Output voltage	VIN=12V
1.9	Shutdown waveform	Time	Output voltage	VIN=12V
1.10	Switching node waveform	Time	Output voltage	VIN=12V
2	EMC performance	Frequency	Power	CISPR25 conductive, emission
3	Thermal measurement	---	---	Tj at each device in operation

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1. Electrical characteristics

1.1. Output ripple waveform

1.1.1 Measurement setup

Measurement setup of output ripple waveform for each power supply ICs is shown below. Those ICs did not measure are disabled by control of Enable signal.

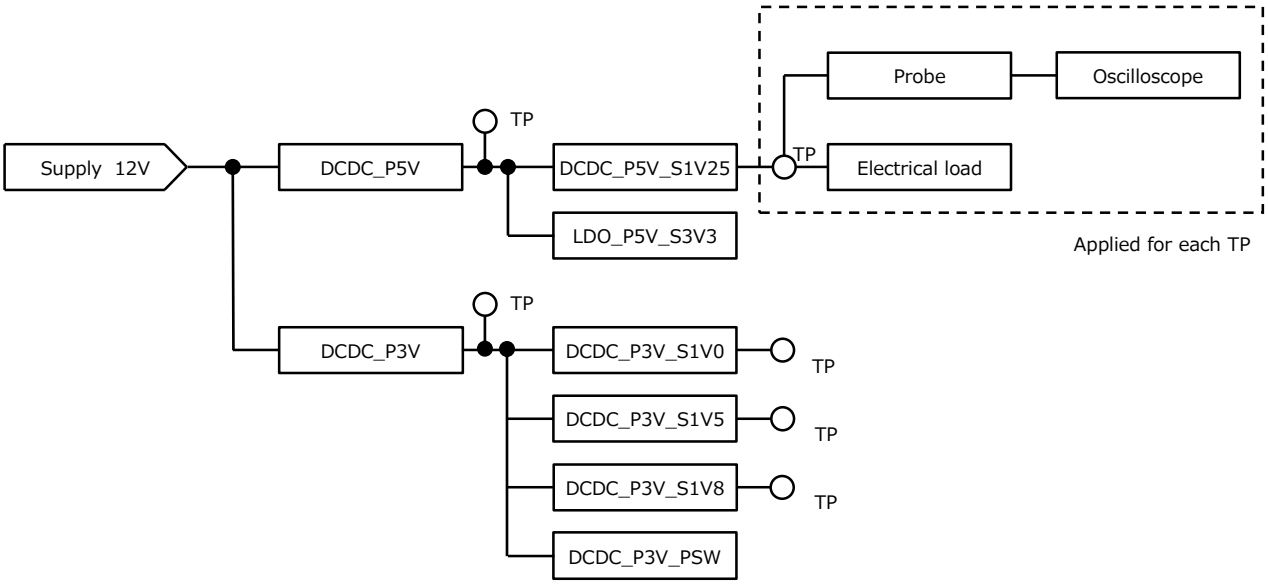

Figure 2 Measurement setup of output ripple waveform

1.1.2 Waveforms

Measurement results of output ripple waveform for each power supply ICs are shown in Figure 3 to Figure 8.

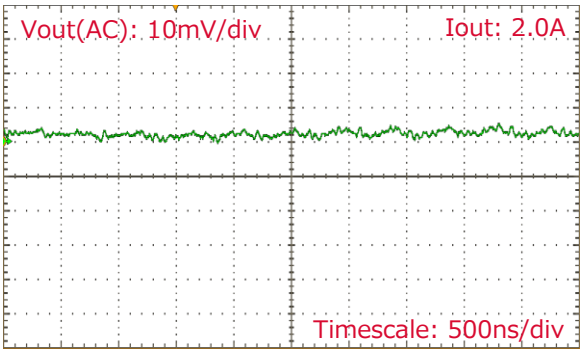

Figure 3 Output ripple waveform of DCDC_P5V

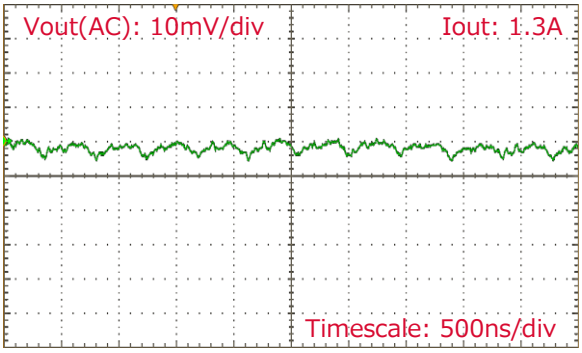

Figure 4 Output ripple waveform of DCDC_P5V_S1V25

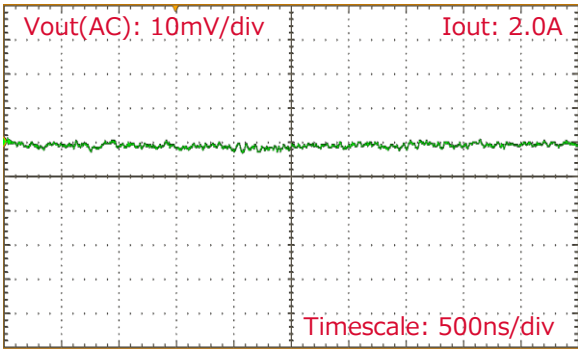

Figure 5 Output ripple waveform of DCDC_P3V

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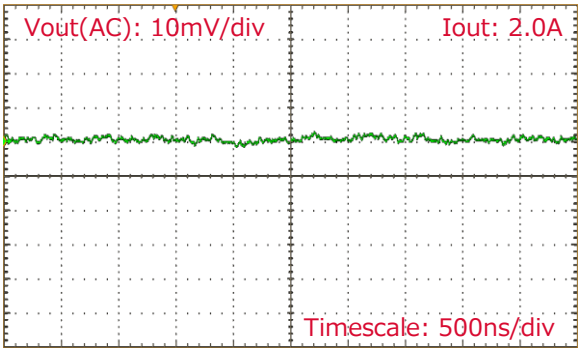

Figure 6 Output ripple waveform of DCDC_P3V_S1V0

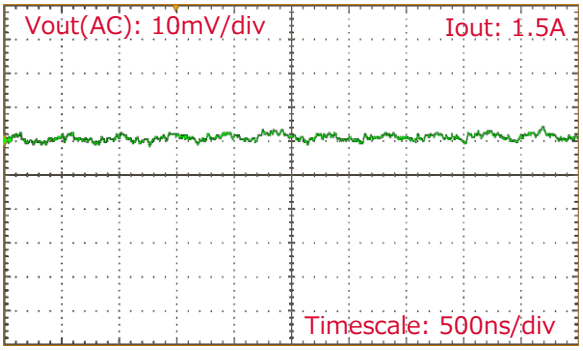

Figure 7 Output ripple waveform of DCDC_P3V_S1V5

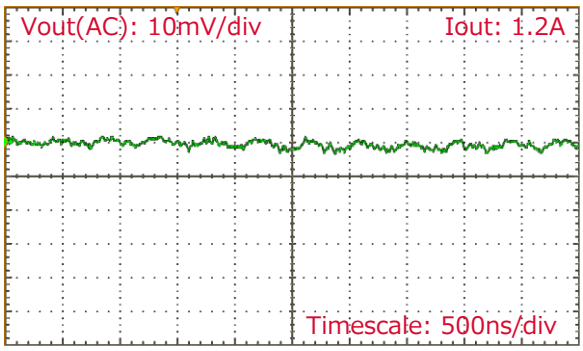

Figure 8 Output ripple waveform of DCDC_P3V_S1V8

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1.2. Conversion efficiency

1.2.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of conversion efficiency for DCDC_P5V and DCDC_P3V is shown below. LEDs and supervisor ICs are removed from board under test while measuring efficiency.

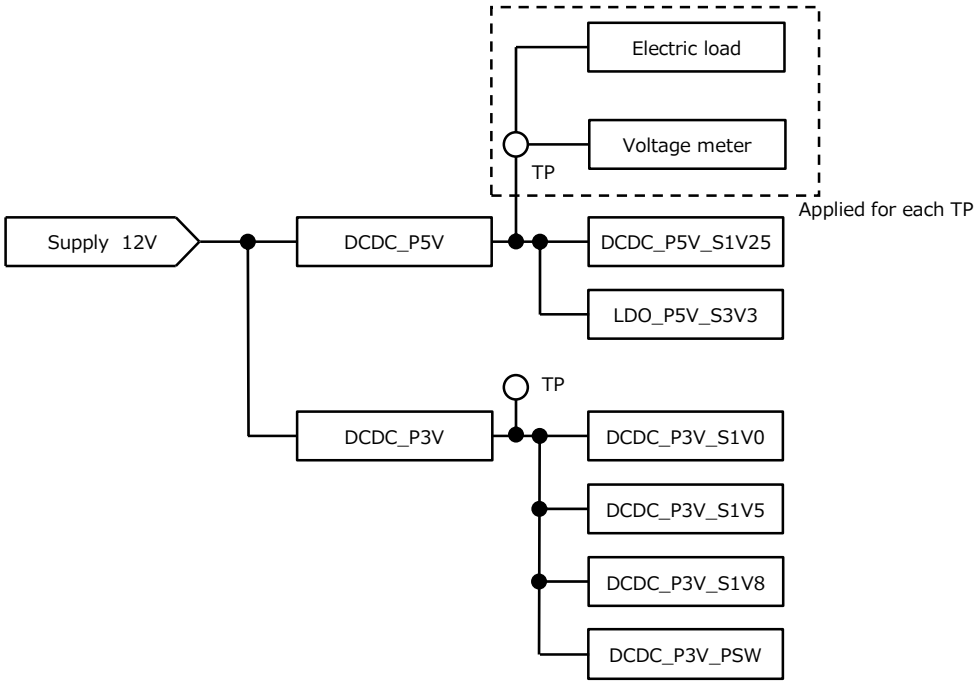

Figure 9 Measurement setup of conversion efficiency and load regulation for DCDC_P5V, DCDC_P3V

1.2.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement results of conversion efficiency for DCDC_P5V and DCDC_P3V are shown in Figure 10 and Figure 11 respectively. ICs are set up as “forced PWM” mode during the measurement.

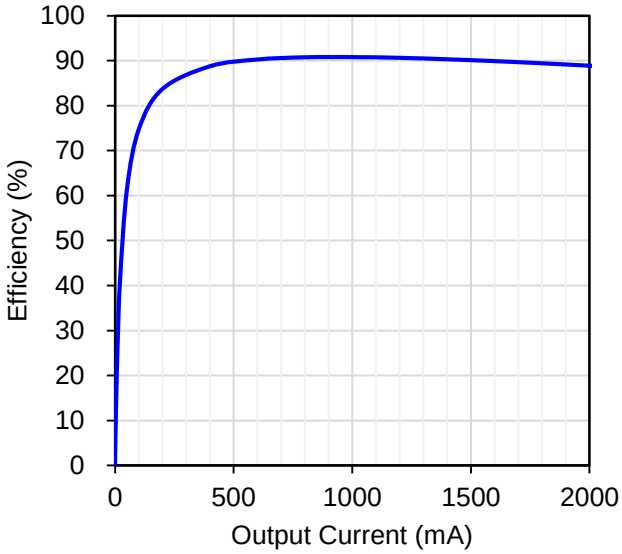

Figure 10 Efficiency of DCDC_P5V

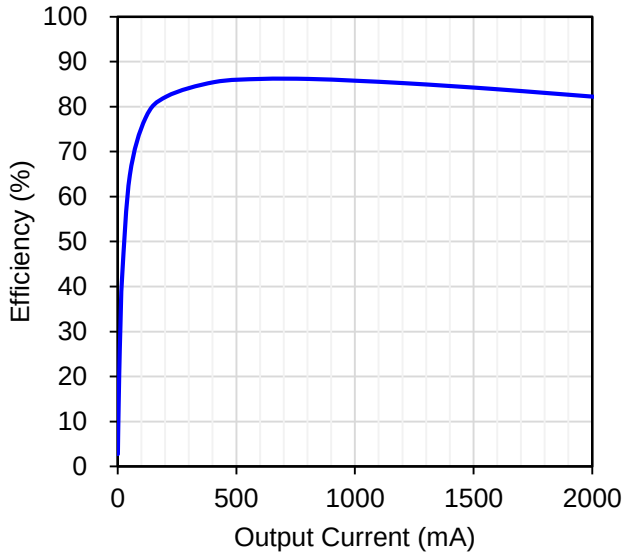

Figure 11 Efficiency of DCDC_P3V

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1.2.3 Measurement setup (for Secondary power supply ICs)

Measurement setup of conversion efficiency for secondary power supplies such as DCDC_P5V_S1V25, DCDC_P3V_S1V0 is shown below. LEDs and supervisor ICs are removed from board under test while measuring efficiency.

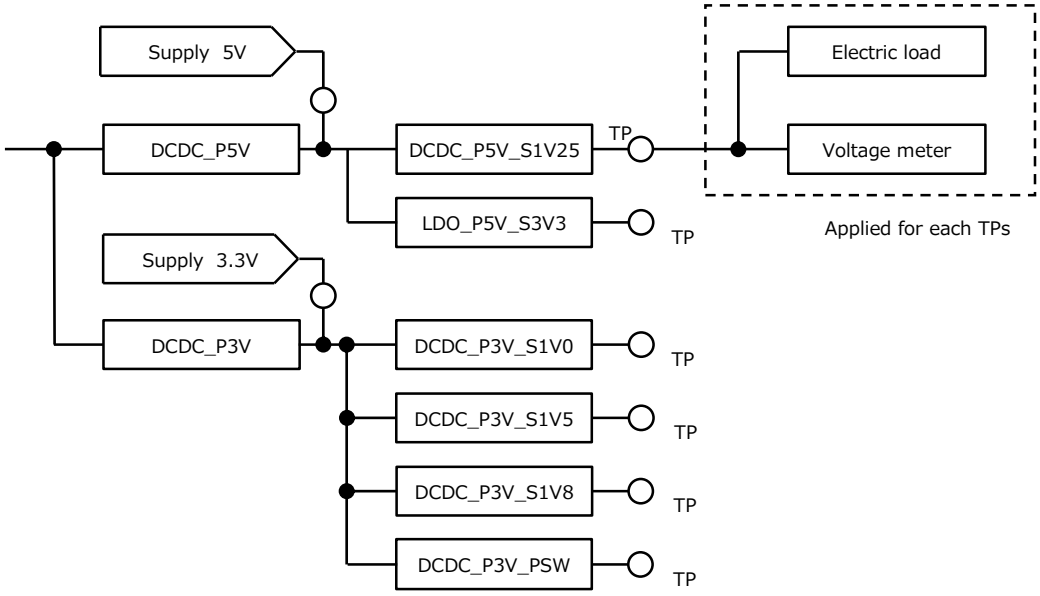

Figure 12 Measurement setup of conversion efficiency and load regulation for secondary power supply ICs.

1.2.4 Measurement result (for Secondary power supply ICs)

Measurement results of conversion efficiency for secondary power supply ICs are shown in Figure 13 to Figure 17.

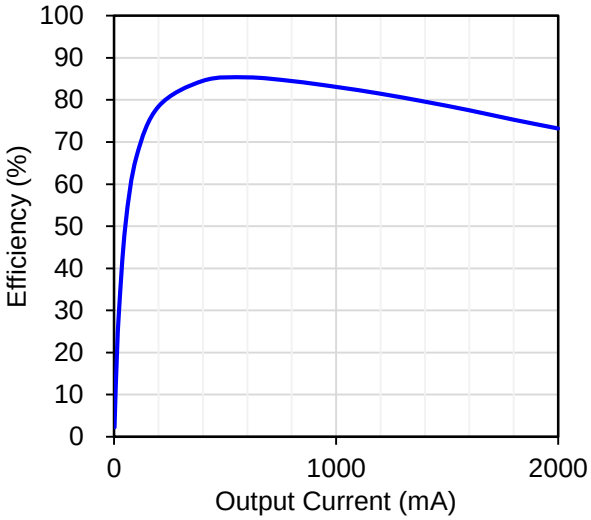

Figure 13 Efficiency of DCDC_P5V_S1V25

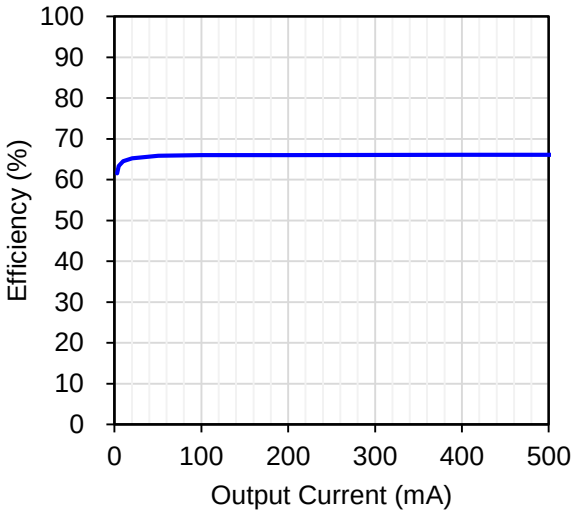

Figure 14 Efficiency of LDO_P5V_S3V3

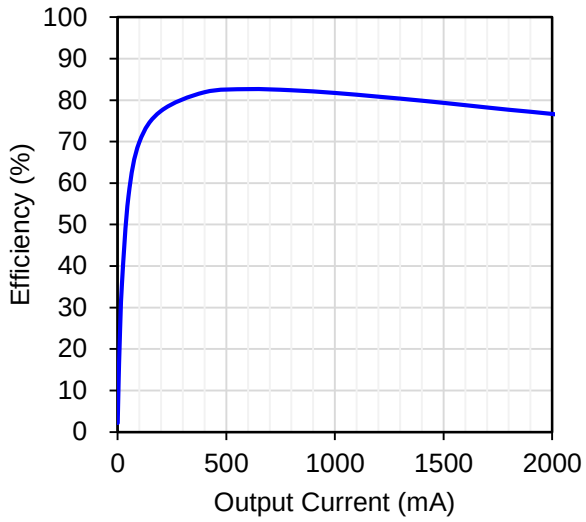

Figure 15 Efficiency of DCDC_P3V_S1V0

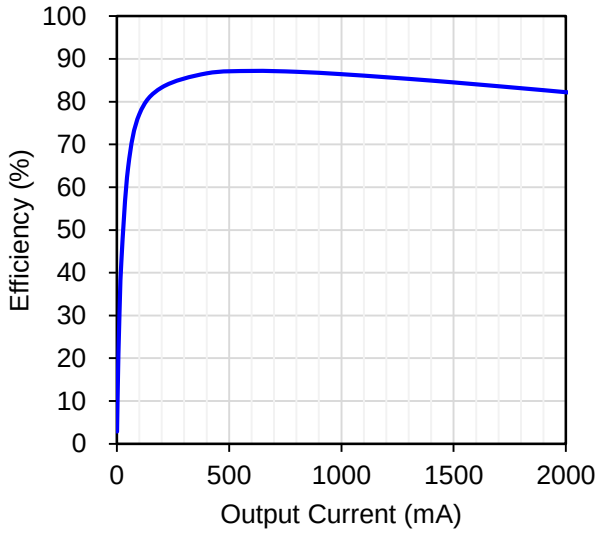

Figure 16 Efficiency of DCDC_P3V_S1V5

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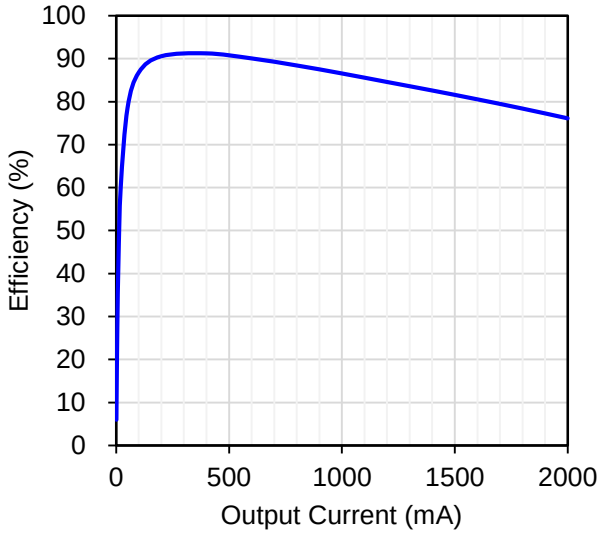

Figure 17 Efficiency of DCDC_P3V_S1V8

1.3. Load regulation

1.3.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of load regulation for DCDC_P5V and DCDC_P3V is same as conversion efficiency, please refer to Figure 9.

1.3.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement results of load regulation for DCDC_P5V and DCDC_P3V are shown in Figure 18 and Figure 19 respectively.

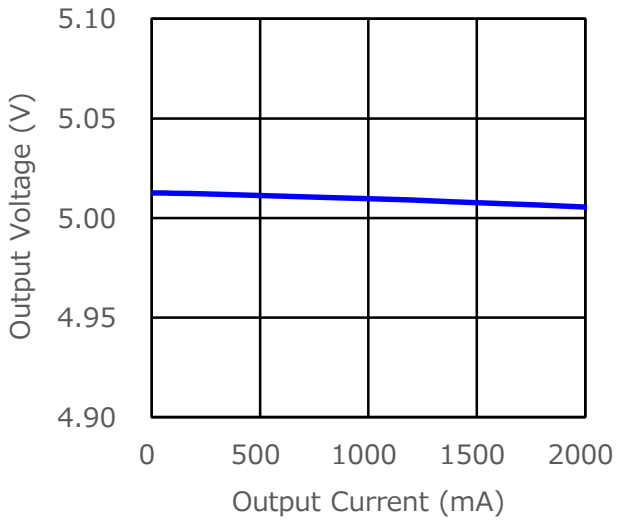

Figure 18 Load regulation of DCDC_P5V

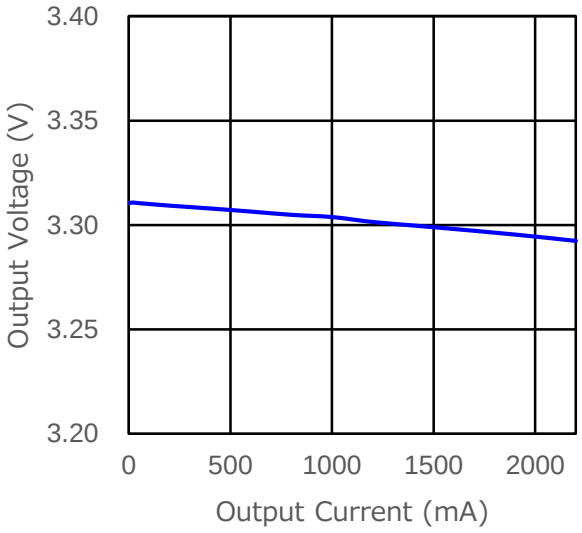

Figure 19 Load regulation of DCDC_P3V

1.3.3 Measurement setup (for secondary power supply ICs)

Measurement setup of load regulation for secondary power supply ICs such as DCDC_P5V_S1V25 and DCDC_P3V_S1V0 etc. are same as conversion efficiency, please refer to Figure 12.

1.3.4 Measurement result (for secondary power supply ICs)

Measurement results of load regulation for power supply ICs are shown in Figure 20and Figure 24.

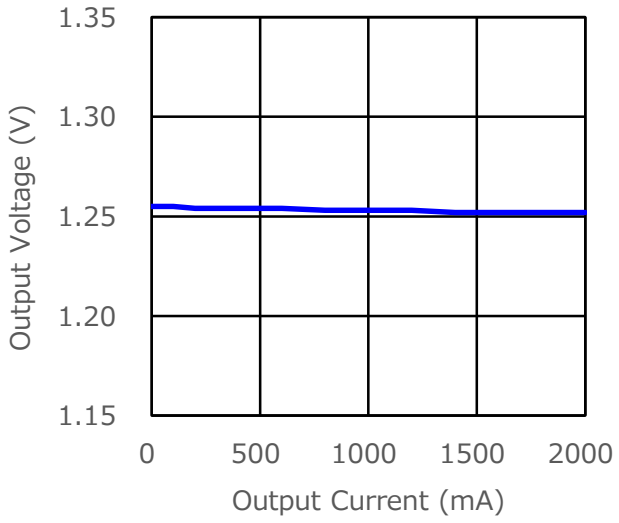

Figure 20 Load regulation of DCDC_P5V_S1V25

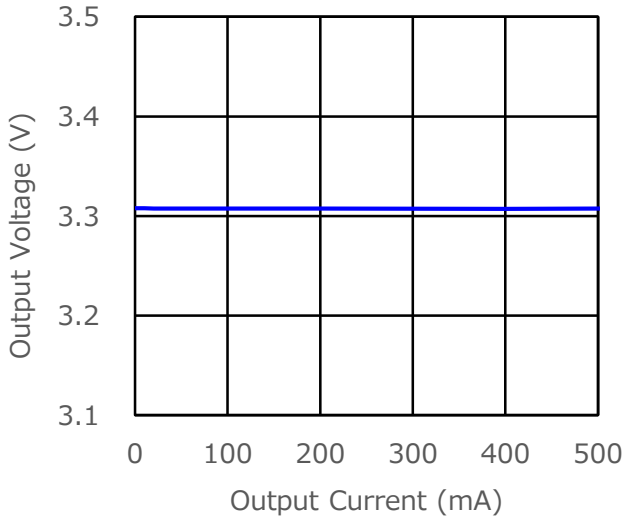

Figure 21 Load regulation of LDO_P5V_S3V3

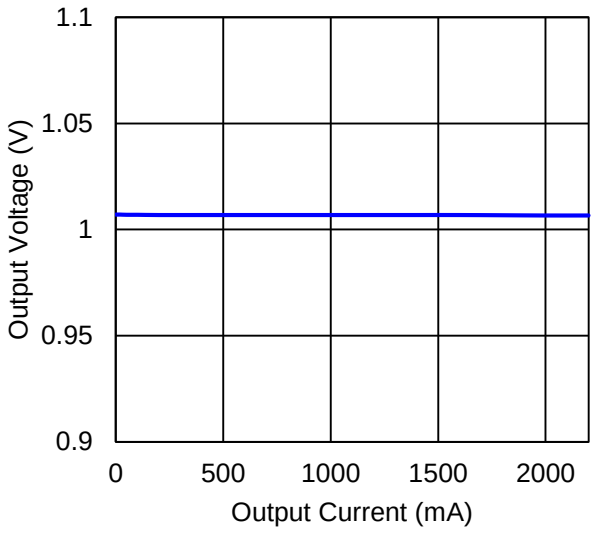

Figure 22 Load regulation of DCDC_P3V_S1V0

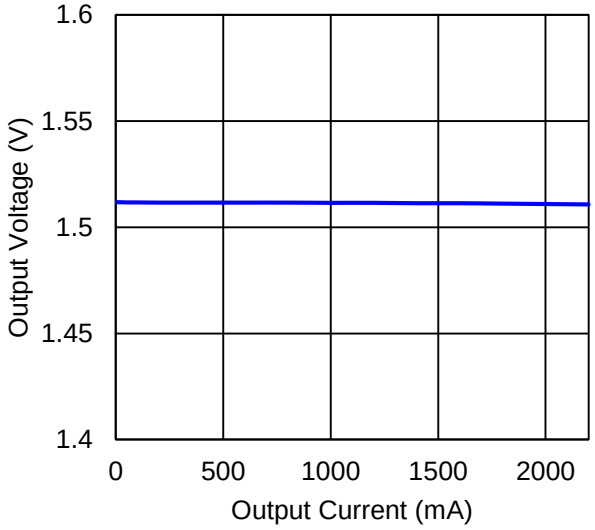

Figure 23 Load regulation of DCDC_P3V_S1V5

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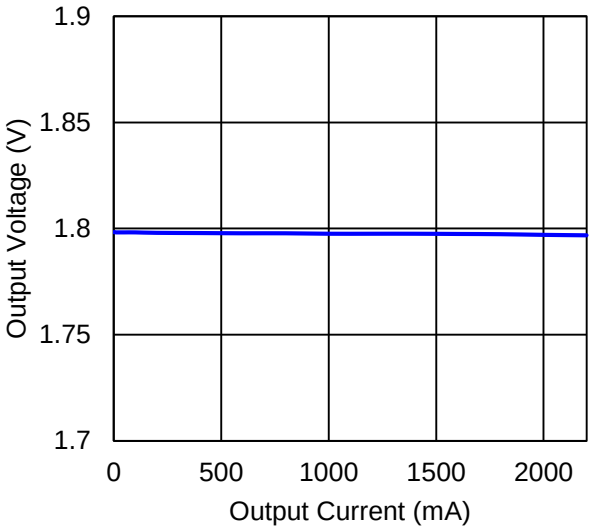

Figure 24 Load regulation of DCDC_P3V_S1V8

1.4. Line regulation

1.4.1 Measurement setup

Measurement setup of line regulation is shown below.

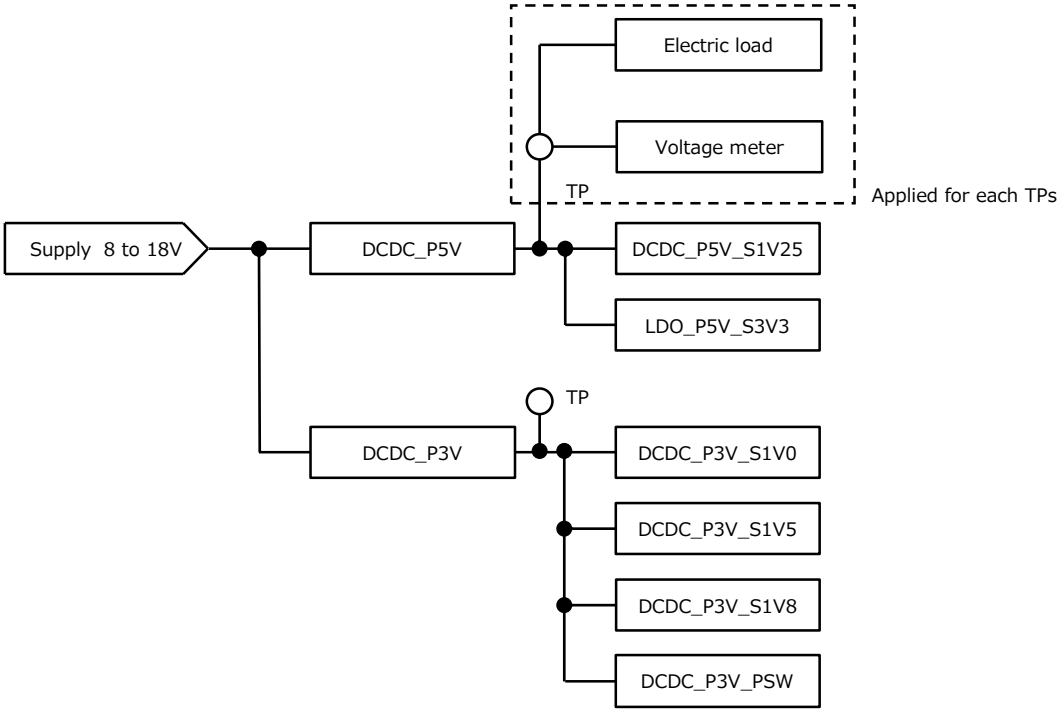

Figure 25 Measurement setup of line regulation

1.4.2 Measurement result

Measurement results of line regulation are shown in Figure 26 and Figure 27.

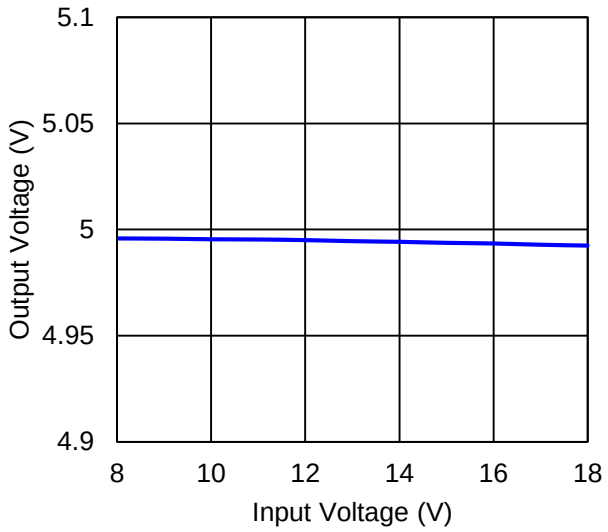

Figure 26 Line regulation of DCDC_P5V

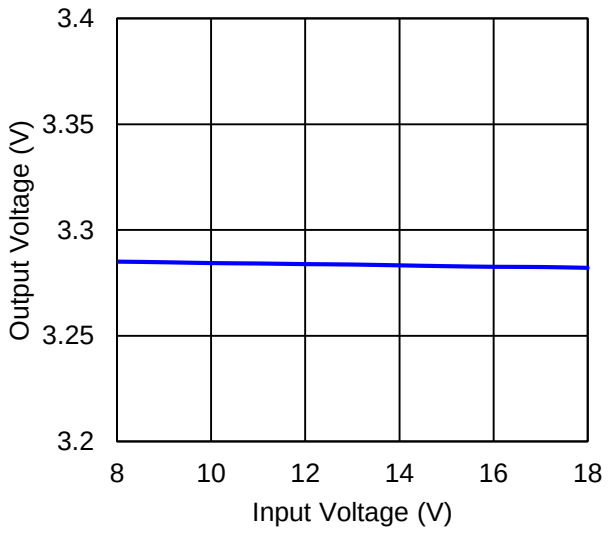

Figure 27 Line regulation of DCDC_P3V

1.5. Shutdown Current

Shutdown current measures the input current while varies the input voltage, All power supply ICs are disabled by controlling the enable signal.

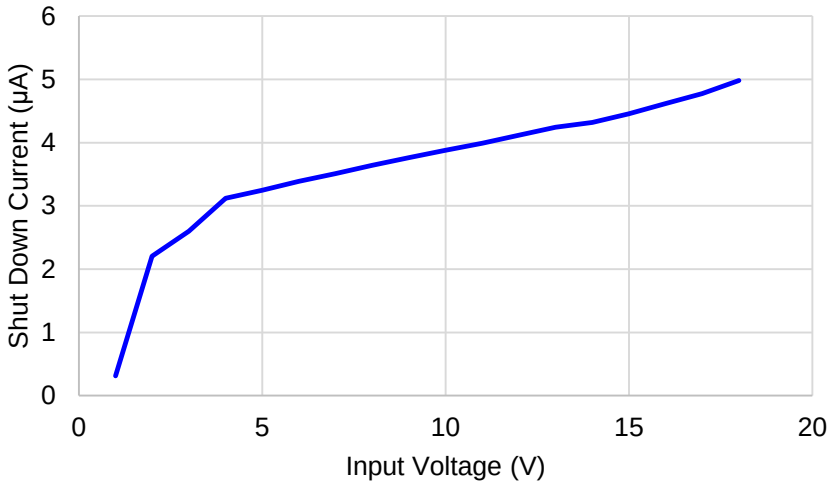

Figure 28 Shutdown Current (Entire board)

1.6. Load response

1.6.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of load response for DCDC_P5V and DCDC_P3V is shown in Figure 29.

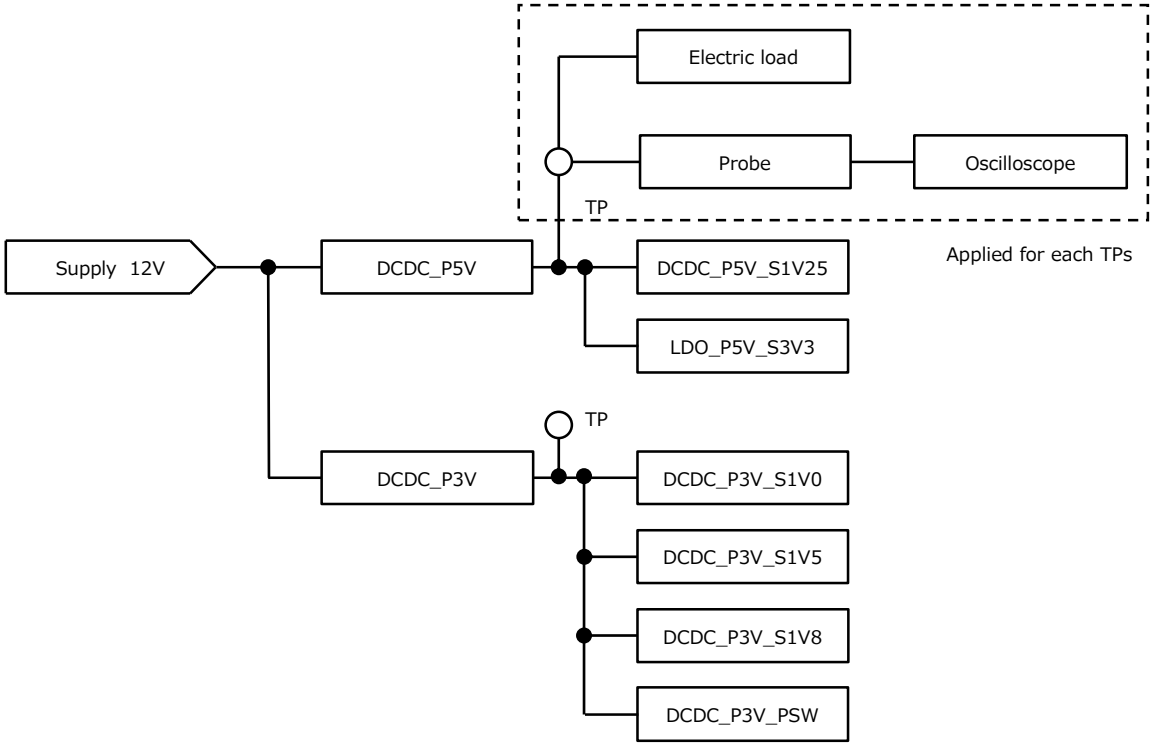

Figure 29 Measurement setup of load response for DCDC_P5V and DCDC_P3V

1.6.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement results of load response for DCDC_P5V and DCDC_P3V are shown in Figure 30 and Figure 31 respectively.

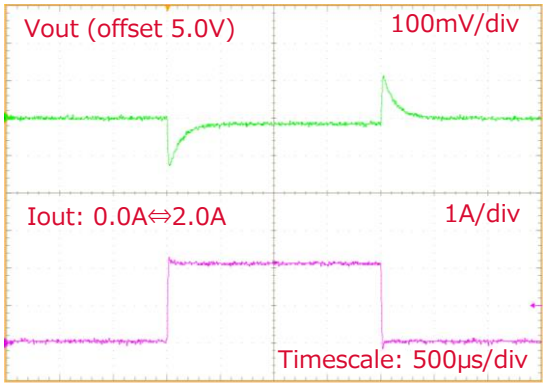

Figure 30 Load response of DCDC_P5V

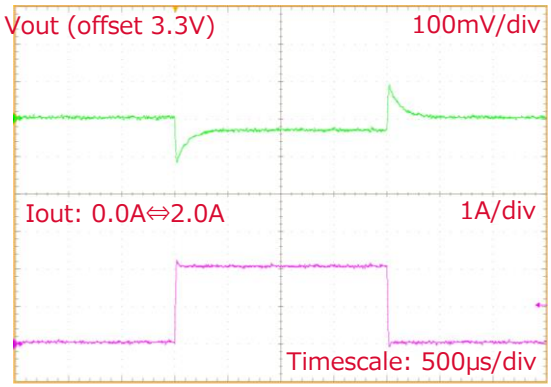

Figure 31 Load response of DCDC_P3V

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1.6.3 Measurement setup (secondary power supply ICs)

Measurement setup of load response for secondary power supply ICs is shown in Figure 32 below.

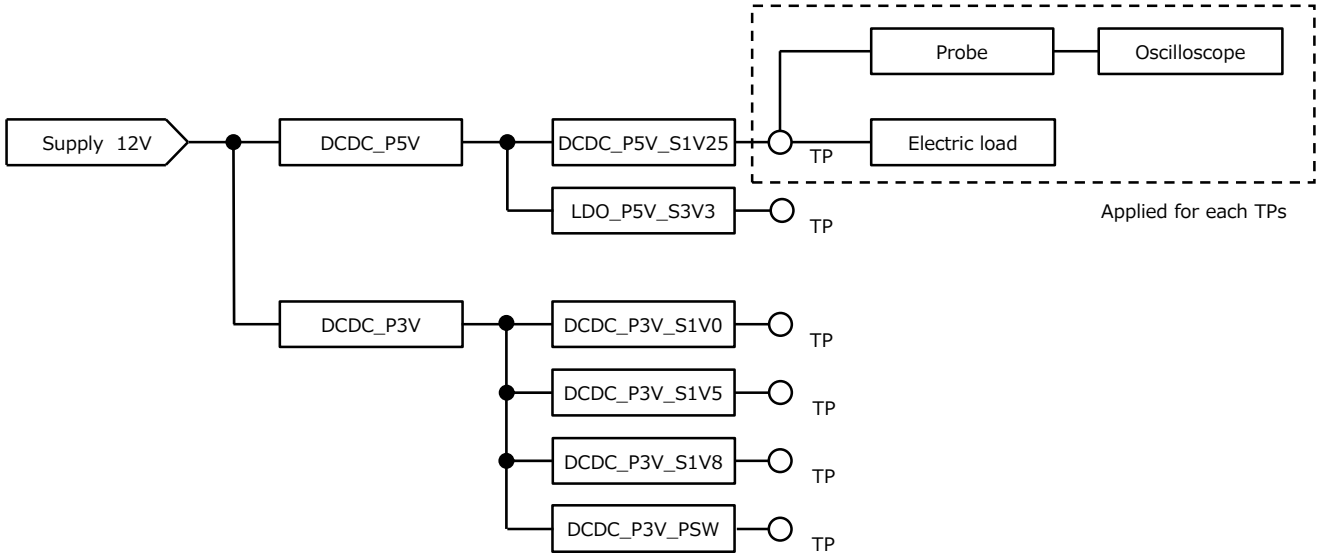

Figure 32 Measurement setup of load response for secondary power supply ICs

1.6.4 Measurement result (secondary power supply ICs)

Measurement results of load responses for secondary power supply ICs are shown in Figure 33 to Figure 38 below.

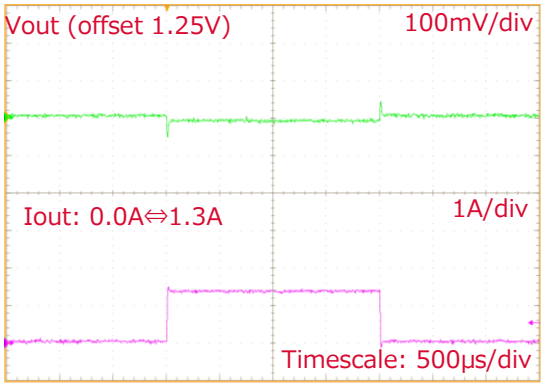

Figure 33 Load response of DCDC_P5V_S1V25

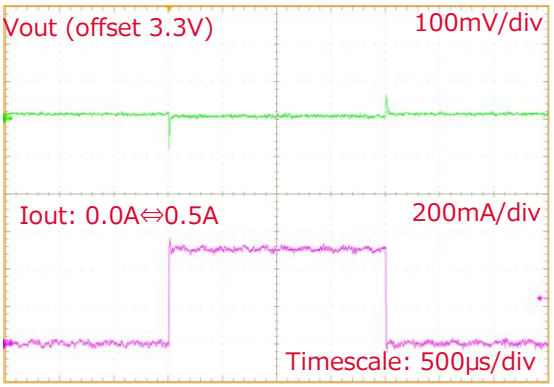

Figure 34 Load response of LDO_P5V_S3V3

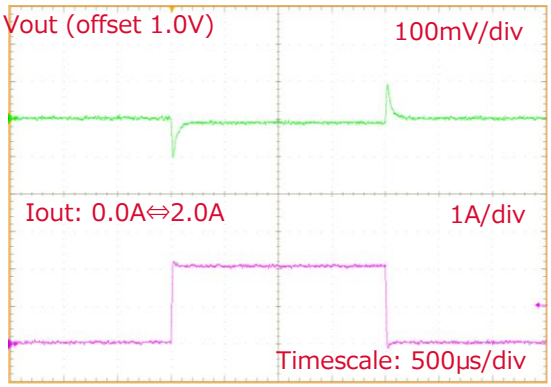

Figure 35 Load response of DCDC_P3V_S1V0

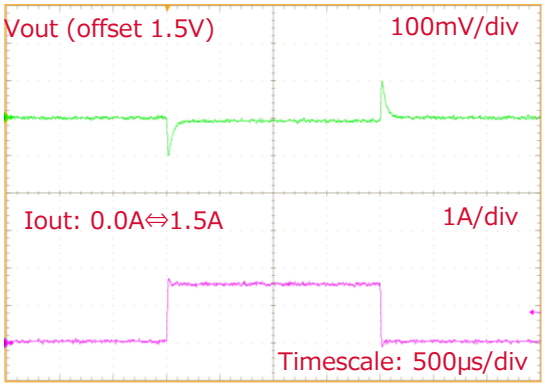

Figure 36 Load response of DCDC_P3V_S1V5

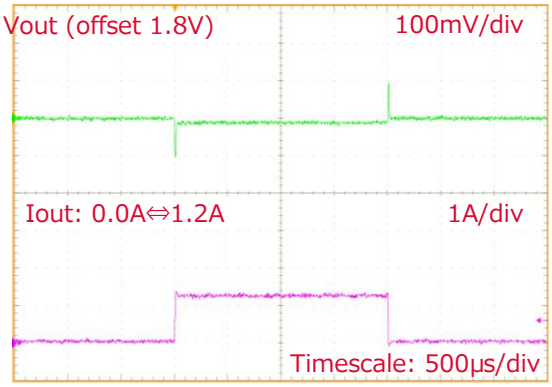

Figure 37 Load response of DCDC_P3V_S1V8

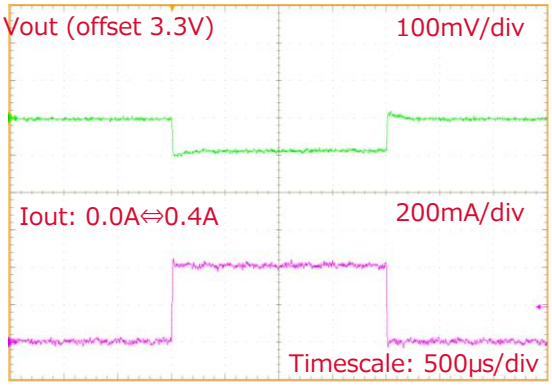

Figure 38 Load response of DCDC_P3V_PSW

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1.7. Phase margin

1.7.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of phase margin for DCDC_P5V and DCDC_P3V is shown in Figure 39.

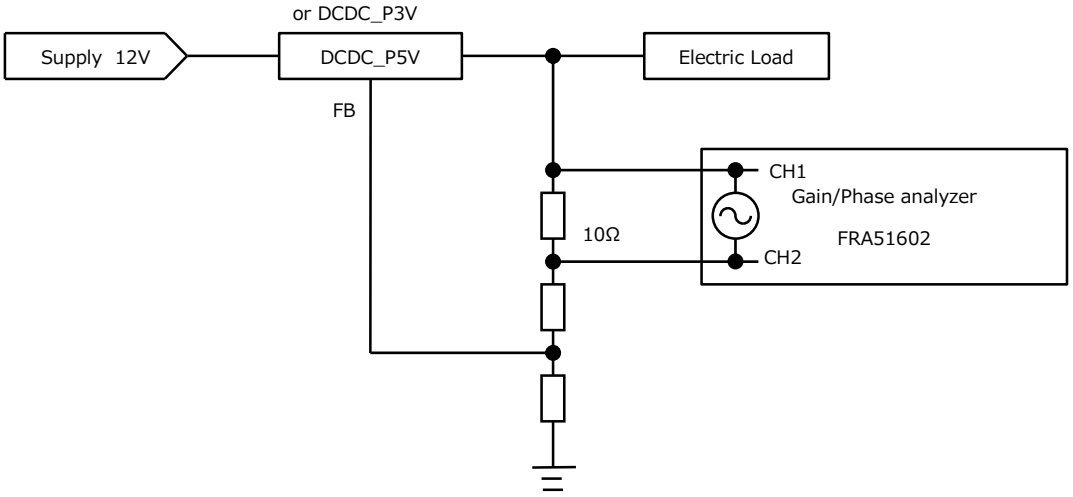

Figure 39 Measurement setup of phase margin for DCDC_P5V and DCDC_P3V

1.7.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement result of phase margin for DCDC_P5V and DCDC_P3V are shown in Figure 40 and Figure 41 respectively.

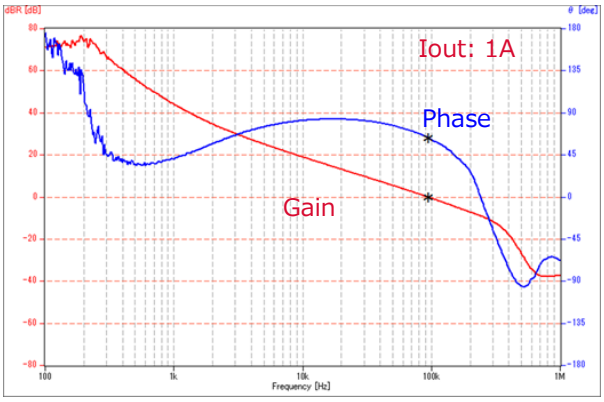

Figure 40 Phase margin of DCDC_P5V

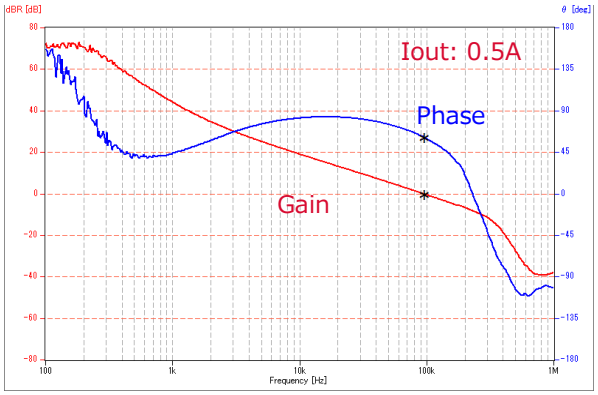

Figure 41 Phase margin of DCDC_P3V

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1.7.3 Measurement setup (for secondary power supply ICs)

Measurement setup of phase margin for secondary power supply ICs is shown in Figure 42.

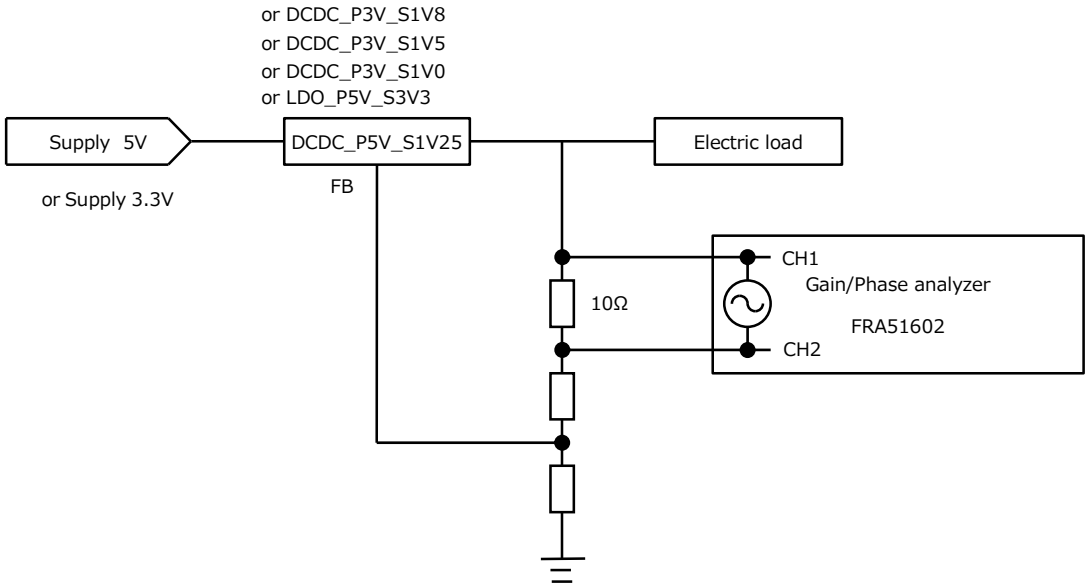

Figure 42 Measurement setup of phase margin for secondary power supply ICs

1.7.4 Measurement result (for secondary power supply ICs)

Measurement results of phase margin for secondary power supply ICs are shown in Figure 43 to Figure 47.

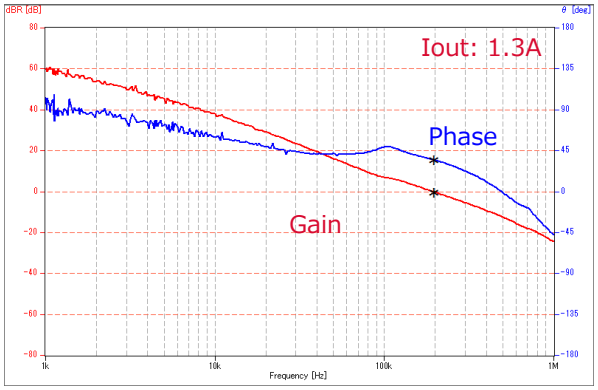

Figure 43 Phase margin of DCDC_P5V_S1V25

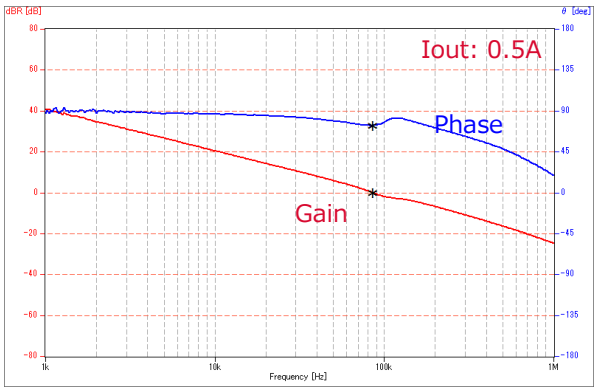

Figure 44 Phase margin of LDO_P5V_S3V3

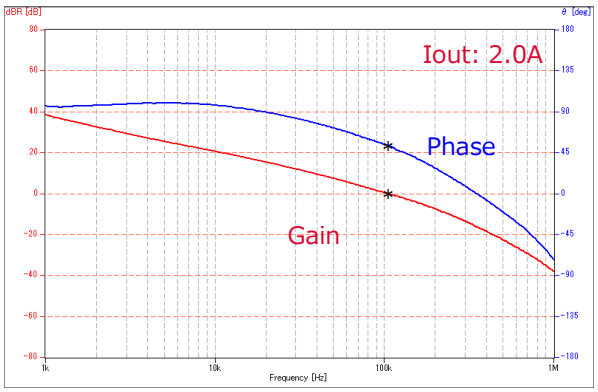

Figure 45 Phase margin of DCDC_P3V_S1V0

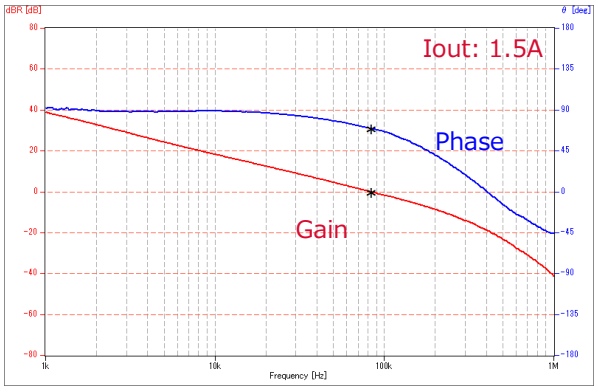

Figure 46 Phase margin of DCDC_P3V_S1V5

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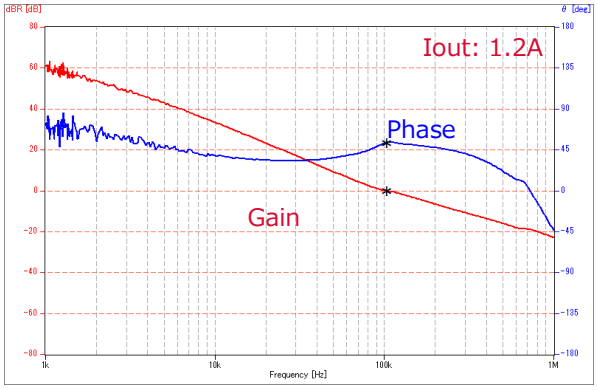

Figure 47 Phase margin of DCDC_P3V_S1V8

1.8. Start-up waveform

1.8.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of starting up waveform and shutdown waveform is shown in Figure 48.

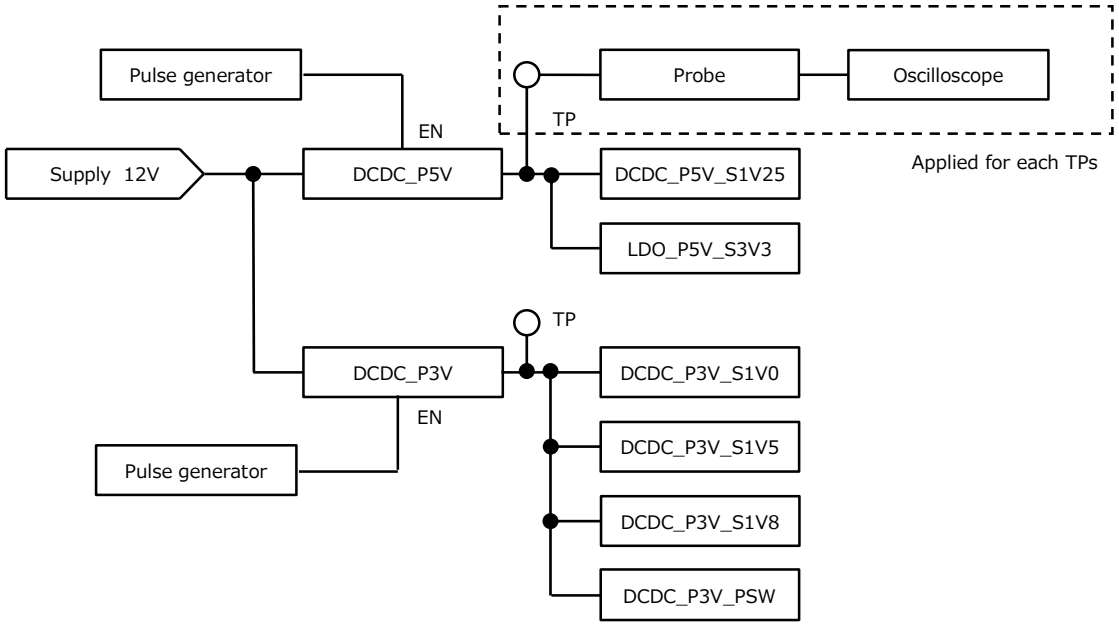

Figure 48 Measurement Setup of Start-up Waveform and Shutdown Waveform for DCDC_P5V and DCDC_P3V

1.8.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement results of start-up waveform for DCDC_P5V and DCDC_P3V are shown in Figure 49 and Figure 50 respectively.

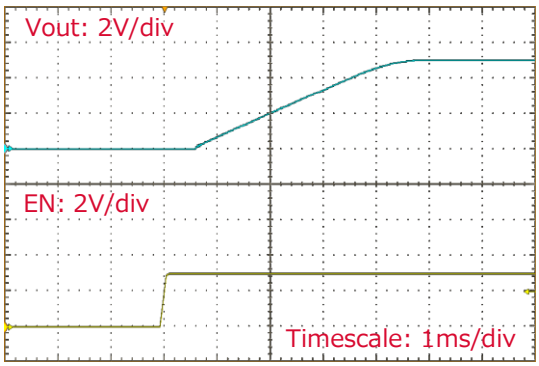

Figure 49 DCDC_P5V start-up waveform

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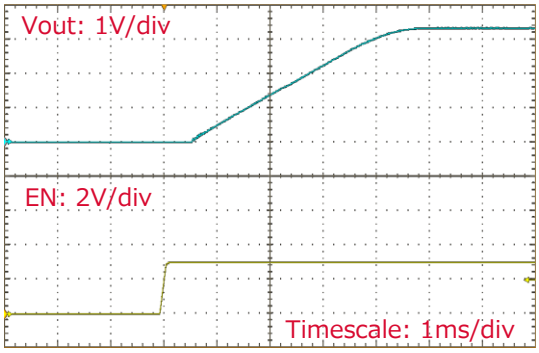

Figure 50 DCDC_P3V start-up waveform

1.8.3 Measurement setup (for secondary power supply ICs)

Measurement setup of start-up waveform and shutdown waveform for secondary power supply ICs is shown in Figure 51.

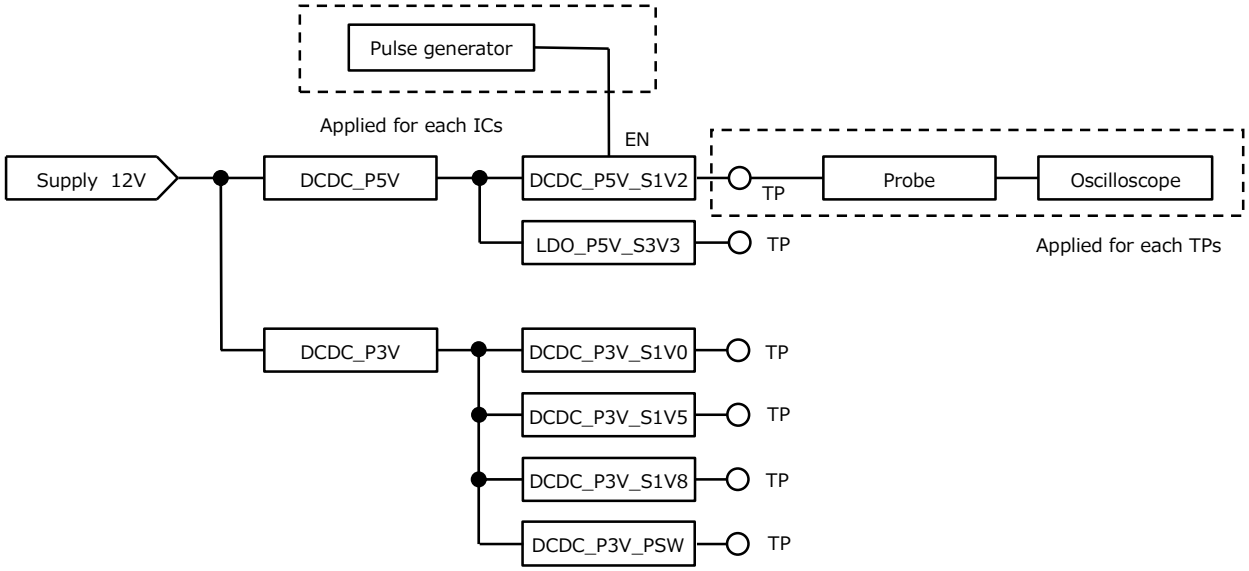

Figure 51 Measurement setup of start-up waveform and shutdown waveform for secondary power supply ICs

1.8.4 Measurement result (for secondary power supply ICs)

Measurement results of start-up waveform for secondary power supply ICs are shown in Figure 52 to Figure 57.

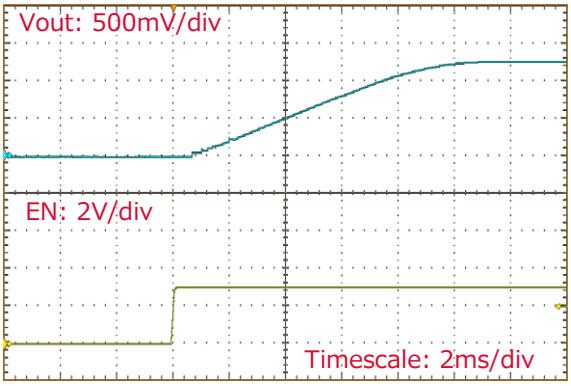

Figure 52 DCDC_P5V_S1V25 start-up waveform

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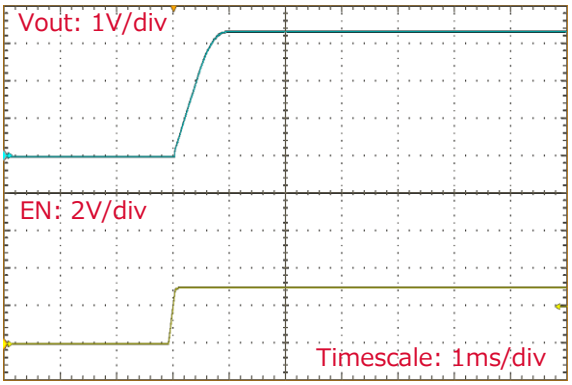

Figure 53 LDO_P5V_S3V3 start-up waveform

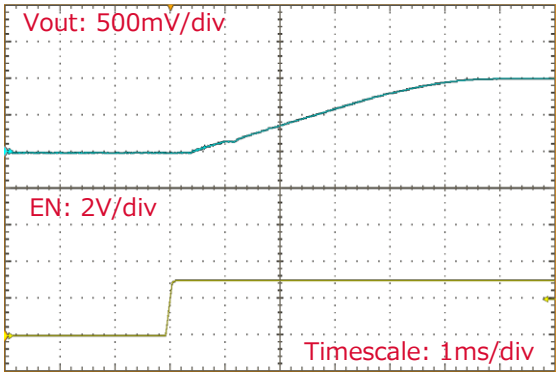

Figure 54 DCDC_P3V_S1V0 start-up waveform

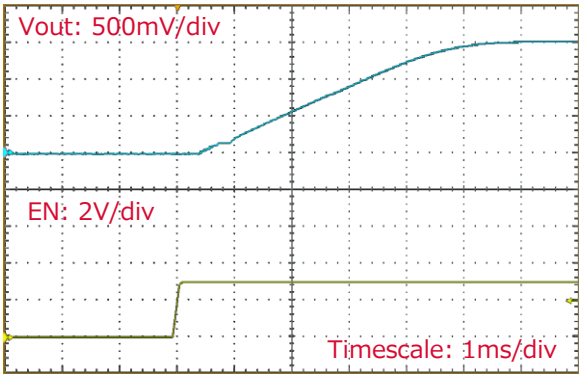

Figure 55 DCDC_P3V_S1V5 start-up waveform

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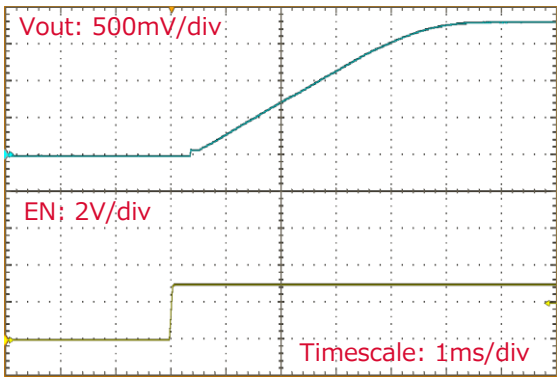

Figure 56 DCDC_P3V_S1V8 start-up waveform

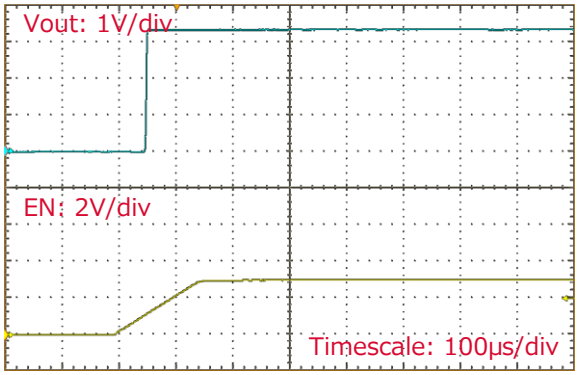

Figure 57 DCDC_P3V_PSW start-up waveform

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1.9. Shutdown waveform

1.9.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of shutdown waveform for DCDC_P5V and DCDC_P3V is shown in Figure 48.

1.9.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement result of shutdown waveform for DCDC_P5V and DCDC_P3V are shown in Figure 58 and Figure 59 respectively.

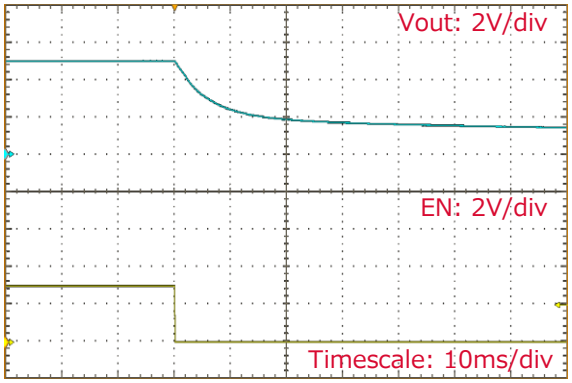

Figure 58 DCDC_P5V shutdown waveform

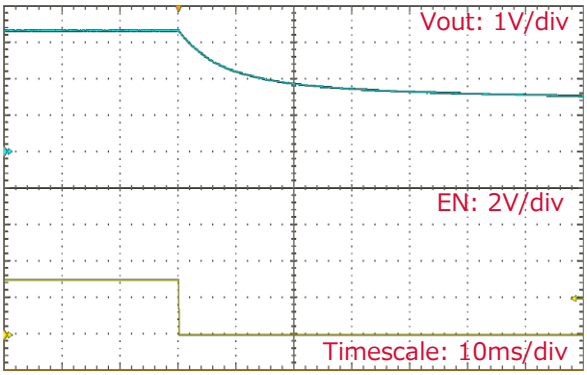

Figure 59 DCDC_P3V shutdown waveform

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1.9.3 Measurement setup (for secondary power supply ICs)

Measurement setup of shutdown waveform for secondary power supply ICs is shown in Figure 51. There is no load applied for output of each power supply.

1.9.4 Measurement result (for secondary power supply ICs)

Measurement results of shutdown waveform for secondary power supply ICs are shown in Figure 60 to Figure 65.

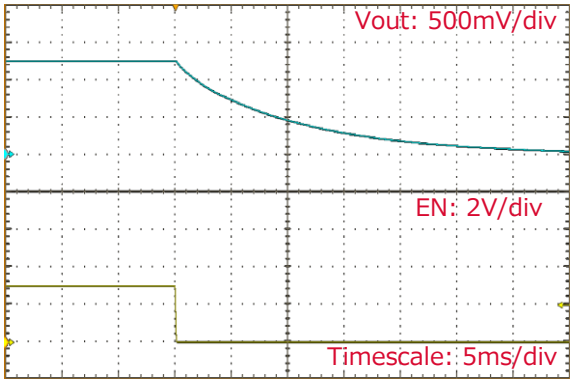

Figure 60 DCDC_P5V_S1V25 shutdown waveform

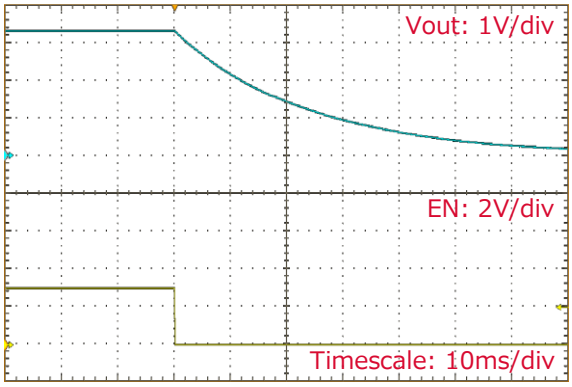

Figure 61 LDO_P5V_S3V3 shutdown waveform

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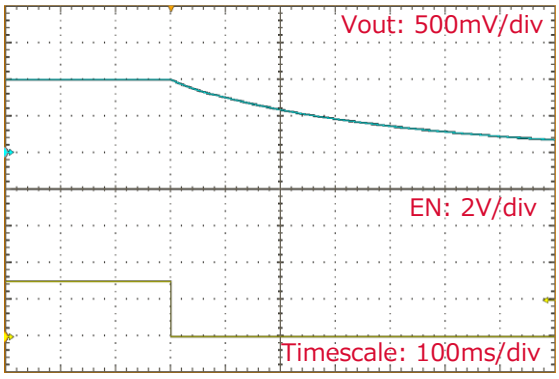

Figure 62 DCDC_P3V_S1V0 shutdown waveform

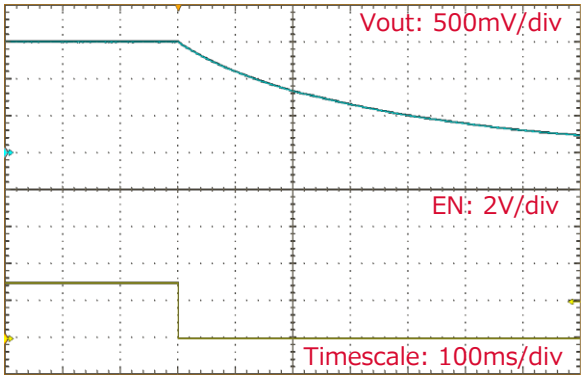

Figure 63 DCDC_P3V_S1V5 shutdown waveform

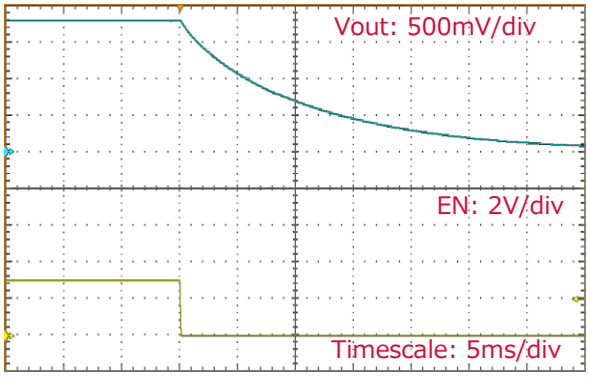

Figure 64 DCDC_P3V_S1V8 shutdown waveform

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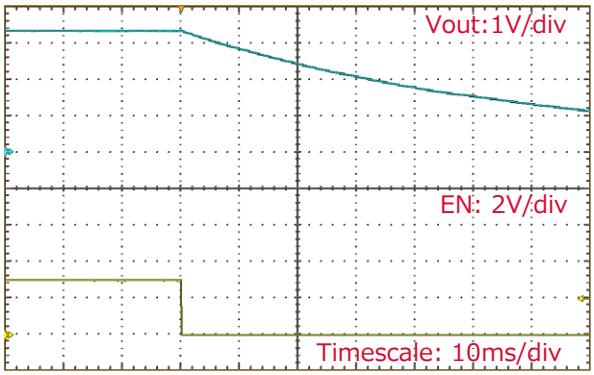

Figure 65 DCDC_P3V_PSW shutdown waveform

1.10. Switching node waveform

1.10.1 Measurement setup (for DCDC_P5V, DCDC_P3V)

Measurement setup of switching node waveform for DCDC_P5V and DCDC_P3V is shown in Figure 66.

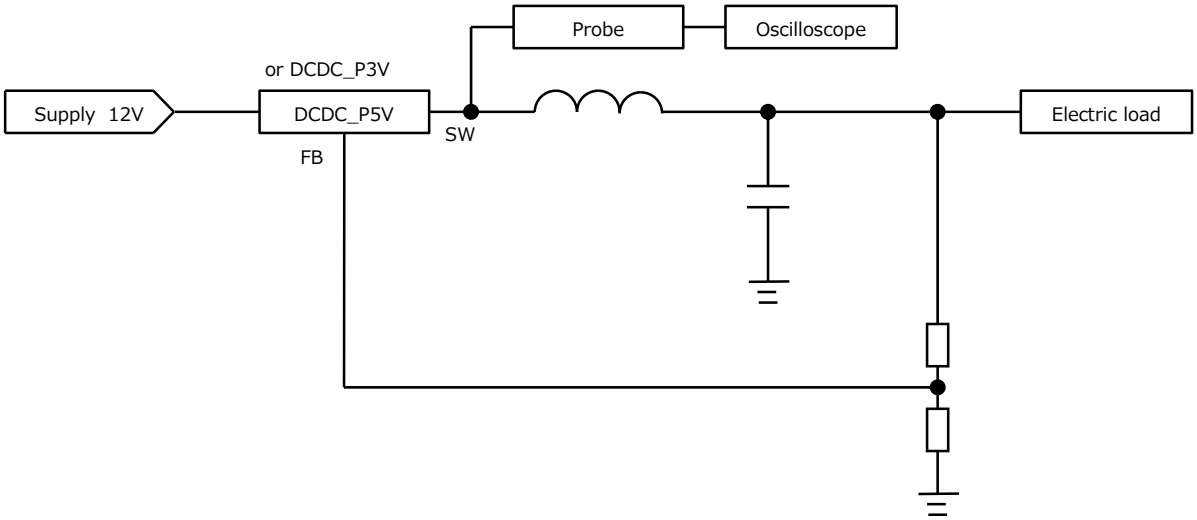

Figure 66 Measurement setup of switching node waveform for DCDC_P5V and DCDC_P3V

1.10.2 Measurement result (for DCDC_P5V, DCDC_P3V)

Measurement results of switching node waveform for DCDC_P5V and DCDC_P3V are shown in Figure 67 and Figure 68 respectively.

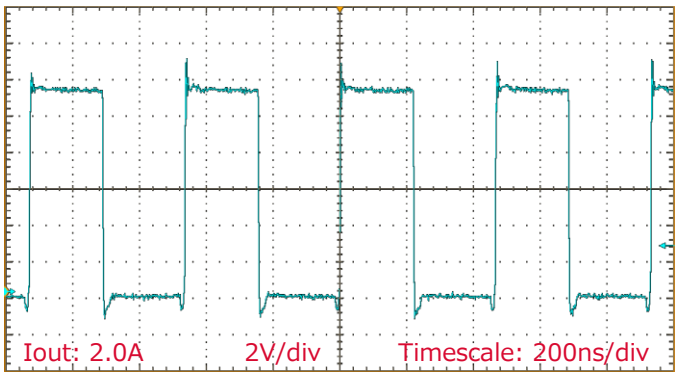

Figure 67 DCDC_P5V switching node waveform

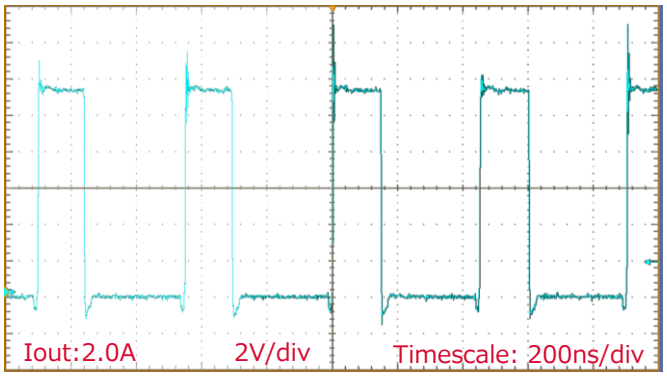

Figure 68 DCDC_P3V switching node waveform

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1.10.3 Measurement setup (for secondary power supply ICs)

Measurement setup of switching node waveform for secondary power supply ICs is shown in Figure 69.

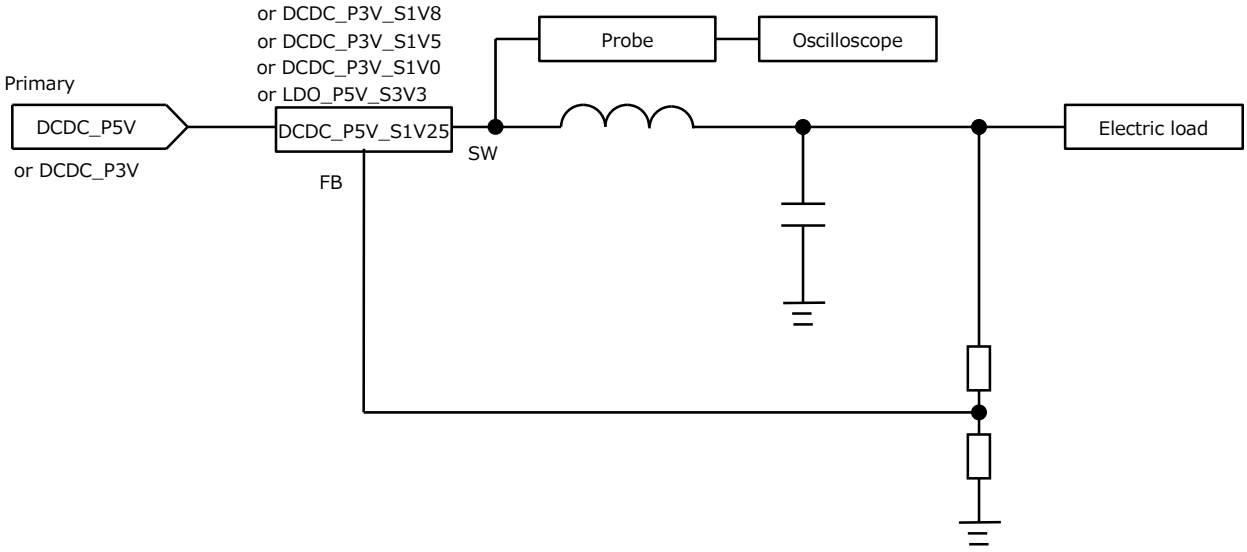

Figure 69 Measurement setup of switching node waveform for secondary power supply ICs

1.10.4 Measurement result (for secondary power supply ICs)

Measurement results of switching node waveform for secondary power supply ICs are shown in Figure 70 to Figure 73.

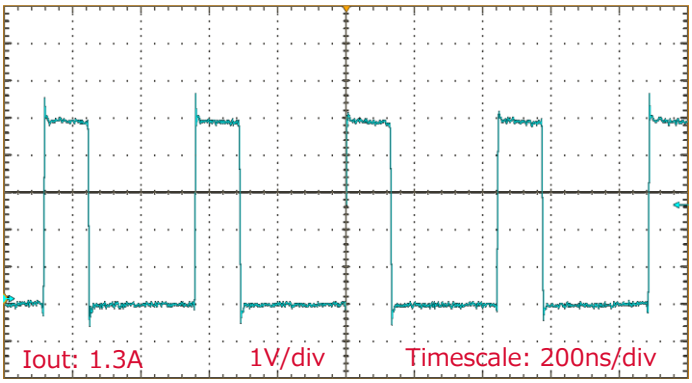

Figure 70 DCDC_P5V_S1V25 switching node waveform

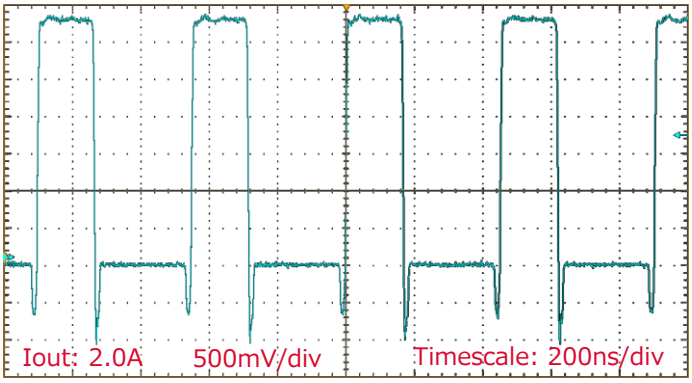

Figure 71 DCDC_P3V_S1V0 switching node waveform

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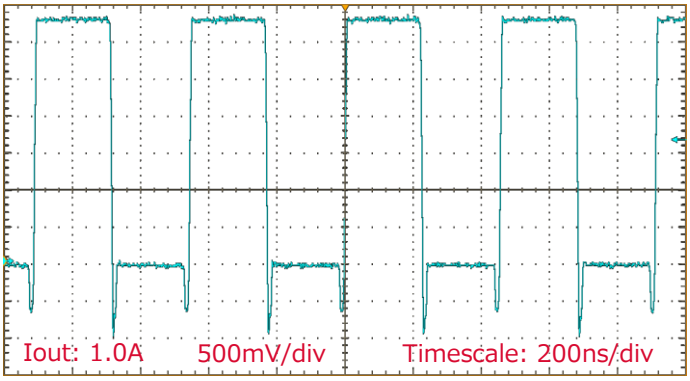

Figure 72 DCDC_P3V_S1V5 switching node waveform

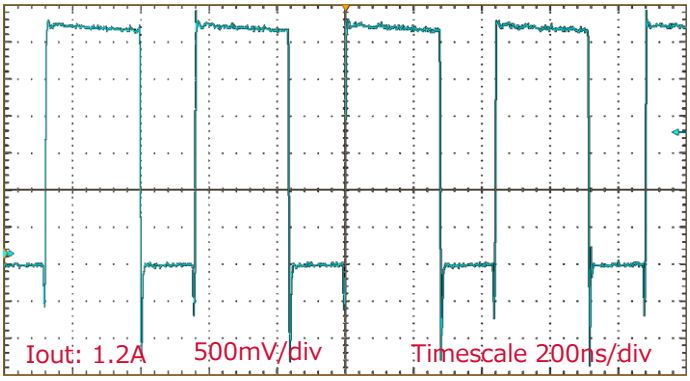

Figure 73 DCDC_P3V_S1V8 switching node waveform

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2. EMC performance

REFRPT001-EVK-001 is able to meet CISPR25 Class5 EMC test standard. In testing, CISPR standard is cleared without a common mode noise filter.

2.1. Operating condition during EMC measurement

Operating condition of each power supply IC during EMC measurement is shown in Table 4.

Table 4 Operating condition of REFRPT001-EVK-001 during EMC measurement

Symbol name	Output loads	Operating condition
DCDC_P5V	Vout=5.02V, Iout=0.3V	Enabled, SSCG ON, Forced PWM mode
DCDC_P5V_S1V25	Vout=1.25V, Iout=1.32A	Enabled
LDO_P5V_S3V3	Vout=3.33V, Iout=0.26A	Enabled
DCDC_P3V	Secondary DCDCs, PSW	Enabled, SSCG ON, Forced PWM mode
DCDC_P3V_S1V0	Vout=1.01V, Iout=2.2A	Enabled, Forced PWM mode
DCDC_P3V_S1V5	Vout=1.52V, Iout=1.49A	Enabled, Forced PWM mode
DCDC_P3V_S1V8	Vout=1.80V, Iout=1.22A	Enabled
DCDC_P3V_PSW	Vout=3.23V, Iout=0.38A	On

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2.2. EMC measurement result

2.2.1 Conductive noise measurement result

Conductive noise measurement result of REFRPT001-EVK-001 is shown in Figure 74.

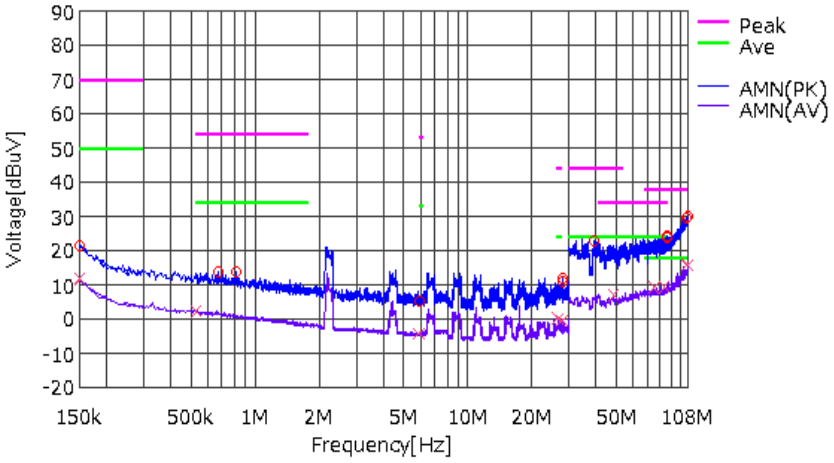

Figure 74 Conductive noise emission of REFRPT001-EVK-001

2.2.2 Radiated noise (Antenna face in horizontal direction) measurement result

Radiated noise with antenna face in horizontal direction of REFRPT001-EVK-001 is shown in Figure 75.

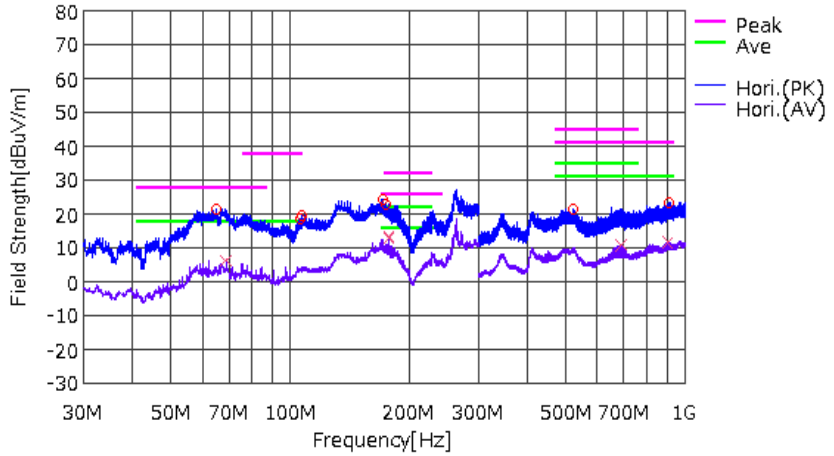

Figure 75 Radiated noise emission (antenna horizontal) of REFRPT001-EVK-001

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2.2.3 Radiated noise (Antenna face in vertical direction) measurement result

Radiated noise with antenna face in vertical direction of REFRPT001-EVK-001 is shown in Figure 76.

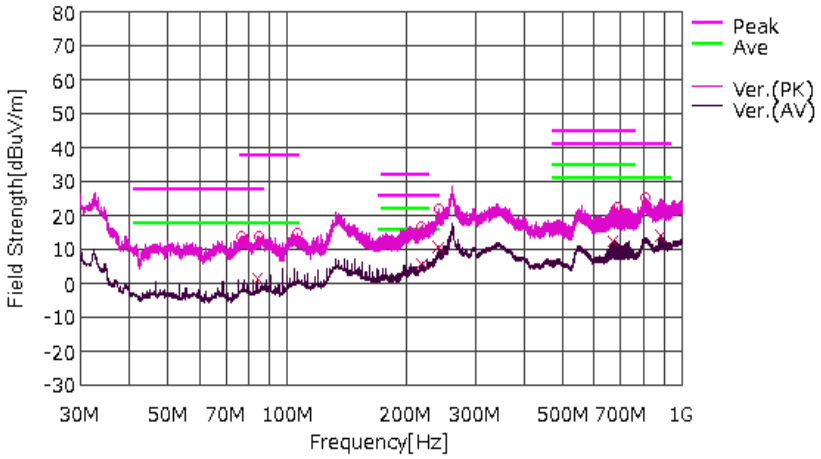

Figure 76 Radiated noise emission (antenna vertical) of REFRPT001-EVK-001

3. Thermal measurement

The following section shows the thermal measurement results of the REFRPT001-EVK-001 under the specified load conditions.

3.1. Measurement setup

In the thermal measurement of REFRPT001-EVK-001, measurement is performed with the following setup.

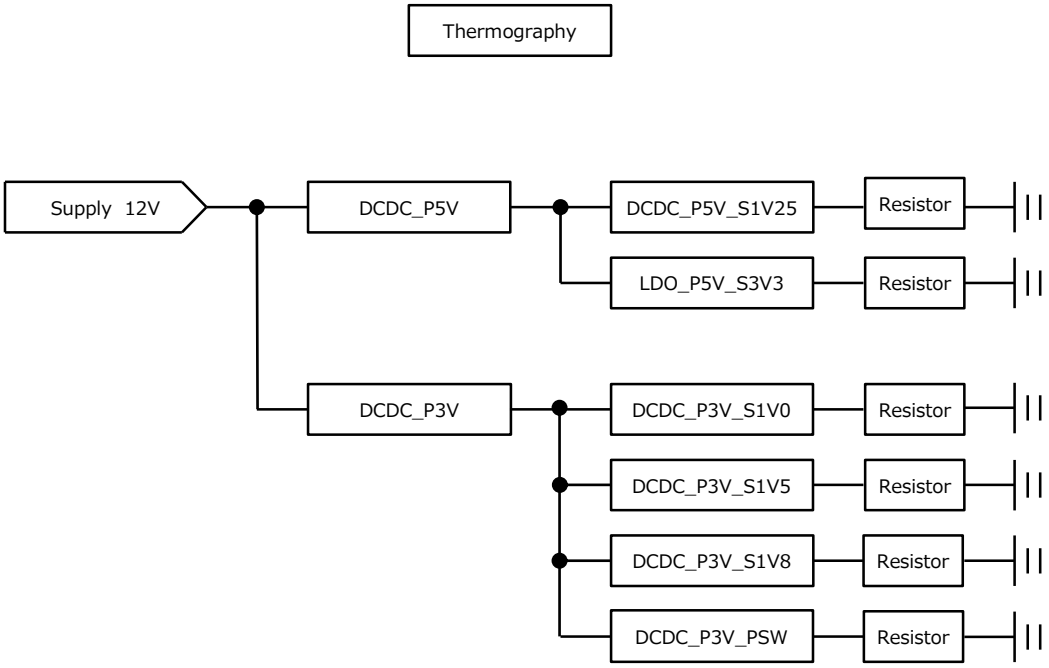

Figure 77 Measurement setup of REFRPT001-EVK-001 during thermal measurement

3.2. Measurement result

Thermal measurement result of REFRPT001-EVK-001 is shown below. Measurement result is shown as the difference from room temperature.

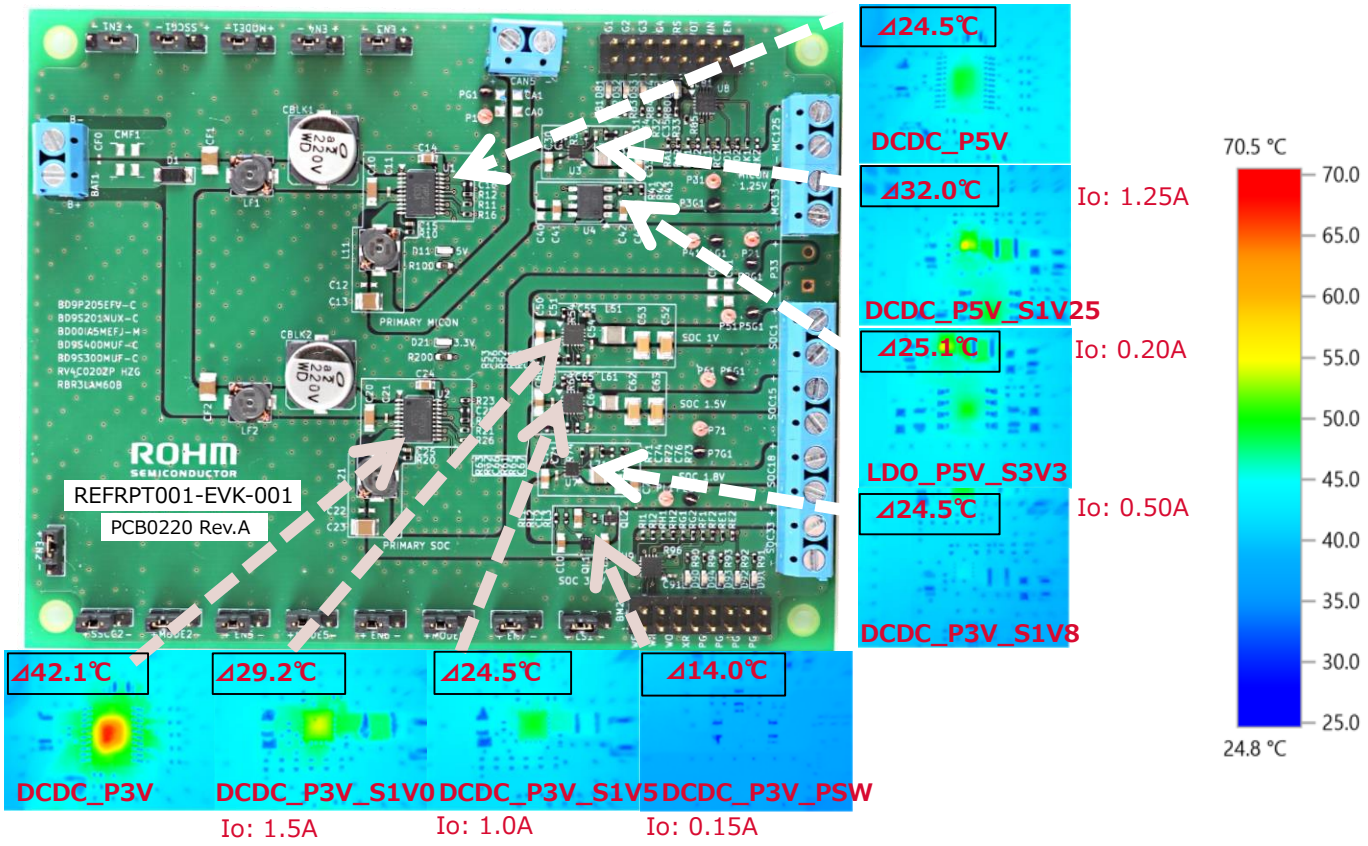

Figure 78 Thermal measurement result of REFRPT001-EVK-001

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