

Features

Regulated Converter

- Wide 36-160VDC input voltage range
- 3kVAC/1min reinforced isolation
- Typical efficiency up to 90%
- Six-sided continuous shield
- EN45545-2, EN50155, UL/IEC/EN62368-1 certified



RPA40-FR

40 Watt
2" x 1"
Single and Dual Output



UL/CAN62368-1 certified
IEC/EN62368-1 certified
EN50155 certified
EN55032 compliant
EN55024 compliant
EN50121-3-2 compliant

Description

The RPA40-FR series wide range input DC/DC converters have been especially designed for railway applications and are EN45545-2, EN50155, and UL/EN/IEC 62368-1 certified. With an input voltage range from 36 to 110VDC and a reinforced isolation barrier rated up to 3kVAC/1min, these high power density converters in a 2" x 1" case are particularly suited for rolling stock rail applications. Despite their small size, the RPA40-FR converters are fully specified devices with output currents up to 8 amps, up to 90% typical efficiency, no minimum load, UVLO, tight regulation, and low ripple/noise figures. The trimmable outputs are also fully protected against over-temperature, short circuits, overcurrent, and overvoltage.

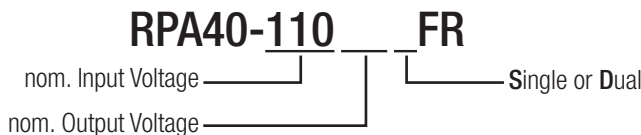
Selection Guide

Part Number	Input Voltage Range [VDC]	Output Voltage [VDC]	Output Current [mA]	Efficiency ⁽¹⁾ typ. [%]	Max. Capacitive Load ⁽²⁾ [µF]
RPA40-11005SFR	36-160	5	8000	88	9600
RPA40-11005.1SFR	36-160	5.1	8000	88	9600
RPA40-11012SFR	36-160	12	3333	89	1667
RPA40-11015SFR	36-160	15	2666	90	1066
RPA40-11024SFR	36-160	24	1666	88.5	417
RPA40-11012DFR	36-160	±12	±1666	88	±833
RPA40-11015DFR	36-160	±15	±1333	89	±533

Notes:

- Note1: Efficiency is tested at nominal input and full load at +25°C ambient
Note2: Max. Cap load is tested at nominal input and full resistive load

Model Numbering



Specifications (measured @ Ta= 25°C, nom. Vin, full load and after warm-up unless otherwise stated)

BASIC CHARACTERISTICS					
Parameter	Condition		Min.	Typ.	Max.
Internal Input Filter			Pi type		
Input Voltage Range			36VDC	110VDC	160VDC
Input Surge Voltage	1s max.				200VDC
Input Current				10mA	
Under voltage Lockout (UVLO)	DC-DC ON				36VDC
	DC-DC OFF		32VDC	34VDC	35.8VDC
Output Voltage Trimming ⁽³⁾	single output only	others	-10%		10%
		15Vout, 24Vout	-10%		20%
Minimum Load			0%		
Start-up time	power up; CTRL ON/OFF			30ms	60ms
Notes: Note3: refer to "OUTPUT VOLTAGE TRIMMING" continued on next page					

Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

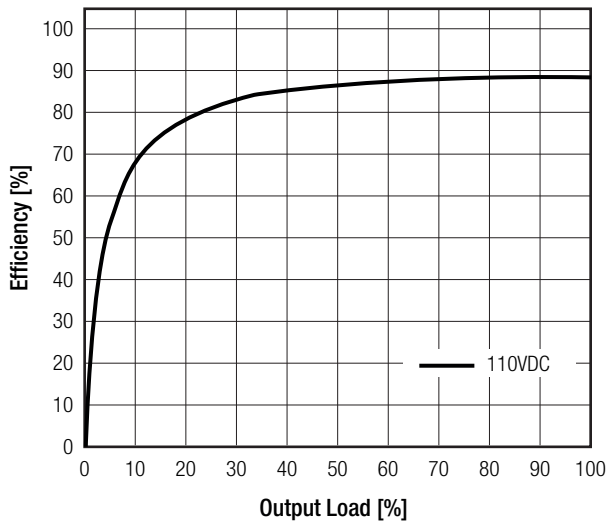
Parameter	Condition		Min.	Typ.	Max.
ON/OFF CTRL	positive logic	DC-DC ON		open or $3\text{VDC} < V_{CTRL} < 12\text{VDC}$	
		DC-DC OFF		short or $0\text{VDC} < V_{CTRL} < 1.2\text{VDC}$	
Input Current of CTRL Pin	DC-DC ON		-0.5mA		+0.5mA
Standby Current	DC-DC OFF			3mA	
Internal Operating Frequency			250kHz	275kHz	310kHz
Output Ripple and Noise ⁽⁴⁾	20MHz BW	5Vout, 5.1Vout		75mVp-p	
		12Vout, 15Vout		100mVp-p	
		24Vout		150mVp-p	

Notes:

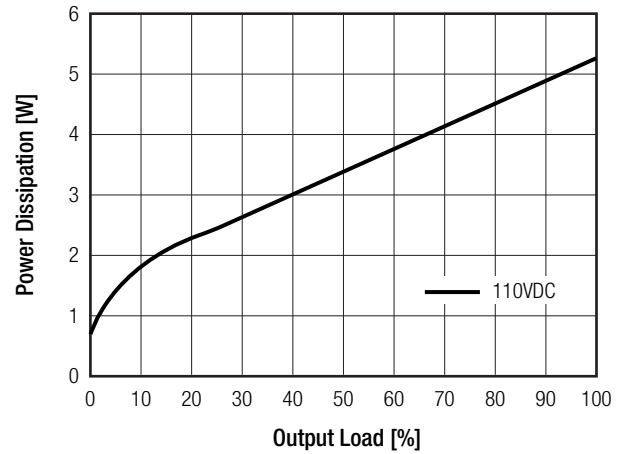
Note4: Measurements are made with a 1.0 μF MLCC across output (low ESR)

RPA40-11012SFR

Efficiency vs. Load

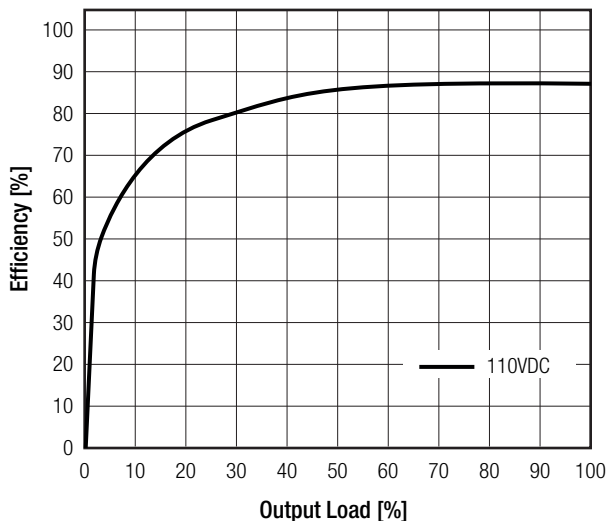


Dissipation vs. Load

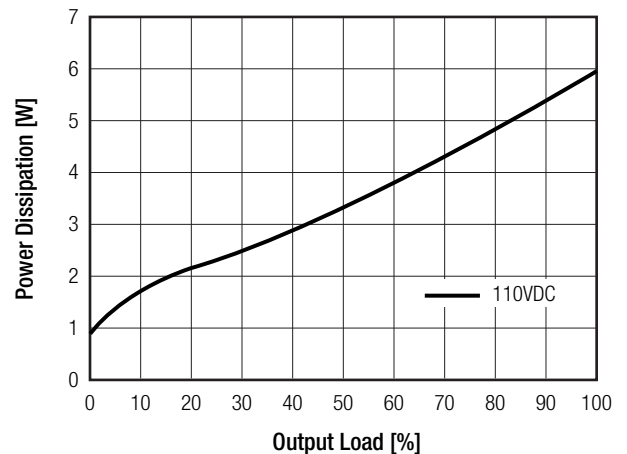


RPA40-11024SFR

Efficiency vs. Load



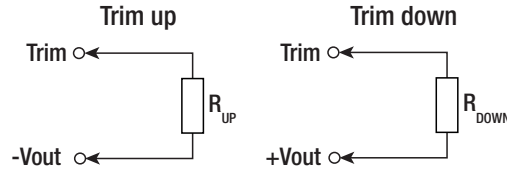
Dissipation vs. Load



Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

OUTPUT VOLTAGE TRIMMING

RPA40-FR converters offer the feature of trimming the output voltage over a certain range around the nominal value by using external trim resistors. The values for trim resistors shown in trim tables below are according to standard E96 values; therefore, the specified voltage may slightly vary; they also can be calculated with below shown equation.



RPA40-11005SFR

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	5.050	5.100	5.150	5.200	5.250	5.300	5.350	5.400	5.450	5.500	[VDC]
$R_{UP} (E96) =$	35k7	16k2	9k76	6k49	4k52	3k16	2k26	1k54	1k	560	[Ω]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_set} =$	4.950	4.900	4.850	4.800	4.750	4.700	4.650	4.600	4.550	4.500	[VDC]
$R_{DOWN} (E96) =$	46k4	21k	12k4	8k25	5k62	4k02	2k8	1k91	1k21	656	[Ω]

RPA40-1105.1SFR

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	5.151	5.202	5.253	5.304	5.355	5.406	5.457	5.508	5.559	5.610	[VDC]
$R_{UP} (E96) =$	36k6	16k7	10k1	6k65	4k64	3k29	2k34	1k62	1k1	620	[Ω]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_set} =$	5.049	4.998	4.947	4.896	4.845	4.794	4.743	4.692	4.641	4.590	[VDC]
$R_{DOWN} (E96) =$	47k5	21k5	13k	8k66	6k04	4k32	3k09	2k15	1k43	866	[Ω]

RPA40-11012SFR

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	12.120	12.240	12.360	12.480	12.600	12.720	12.840	12.960	13.080	13.200	[VDC]
$R_{UP} (E96) =$	393k	174k	102k	66k5	45k3	32k4	22k1	15k	9k31	4k64	[Ω]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_set} =$	11.880	11.760	11.640	11.520	11.400	11.280	11.160	11.040	10.920	10.800	[VDC]
$R_{DOWN} (E96) =$	432k	200k	121k	78k7	54k9	38k3	26k7	17k4	10k7	5k11	[Ω]

RPA40-11015SFR

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	15.150	15.300	15.450	15.600	15.750	15.900	16.050	16.200	16.350	16.500	[VDC]
$R_{UP} (E96) =$	412k	200k	127k	88k7	68k1	53k6	42k2	34k8	28k7	23k7	[Ω]
$\Delta V_{out} =$	11	12	13	14	15	16	17	18	19	20	[%]
$V_{out_set} =$	16.650	16.800	16.950	17.100	17.250	17.400	17.550	17.700	17.850	18.000	[VDC]
$R_{UP} (E96) =$	20k	16k5	13k7	11k3	9k31	7k5	5k76	4k42	3k09	1k96	[Ω]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_set} =$	14.850	14.700	14.550	14.400	14.250	14.100	13.950	13.800	13.650	13.500	[VDC]
$R_{DOWN} (E96) =$	301k	133k	78k7	51k1	35k7	24k9	17k4	11k8	7k5	3k92	[Ω]

continued on next page

Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

RPA40-11024SFR

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	24.240	24.480	24.720	24.960	25.200	25.440	25.680	25.920	26.160	26.400	[VDC]
$R_{UP} (E96) =$	953k	475k	301k	215k	165k	127k	102k	82k5	68k1	56k2	[Ω]
$\Delta V_{out} =$	11	12	13	14	15	16	17	18	19	20	[%]
$V_{out_set} =$	26.640	26.880	27.120	27.360	27.600	27.840	28.080	28.320	28.560	28.800	[VDC]
$R_{UP} (E96) =$	46k4	38k3	30k9	24k9	20k	15k4	11k3	7k68	4k53	1k62	[Ω]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_set} =$	23.760	23.520	23.280	23.040	22.800	22.560	22.320	22.080	21.840	21.600	[VDC]
$R_{DOWN} (E96) =$	732k	324k	191k	127k	86k6	59k	40k2	26k1	15k4	6k49	[Ω]

REGULATIONS

Parameter	Condition		Value
Output Accuracy			$\pm 1.0\%$
Line Regulation	low line to high line, full load	Single	$\pm 0.2\%$
		Dual	$\pm 0.5\%$
Load Regulation	0% to 100% load	Single	0.5%
		Dual	1.0%
Cross Regulation	asymmetrical 25% / 100% load		$\pm 5.0\%$
Transient Response	25% load step change		250 μs typ.

PROTECTIONS

Parameter	Condition		Value
Short Circuit Protection (SCP)			continuous, automatic recovery
Over Voltage Protection (OVP)	zener diode clamp	5Vout, 5.1Vout	6.2VDC typ.
		12Vout	15VDC typ.
		15Vout	20VDC typ.
		24Vout	30VDC typ.
Over Load Protection (OLP)	% of rated I_{OUT}		150% typ., hiccup mode
Over Temperature Protection (OTP)	internal temperature sensor		115 $^\circ\text{C}$ typ.
Isolation Voltage ⁽⁵⁾	I/P to O/P	1 minute	3kVAC
Isolation Resistance	$V_{ISO} = 500\text{VDC}$		1G Ω min.
Isolation Capacitance			1000pF max.
Insulation Grade			reinforced

Notes:

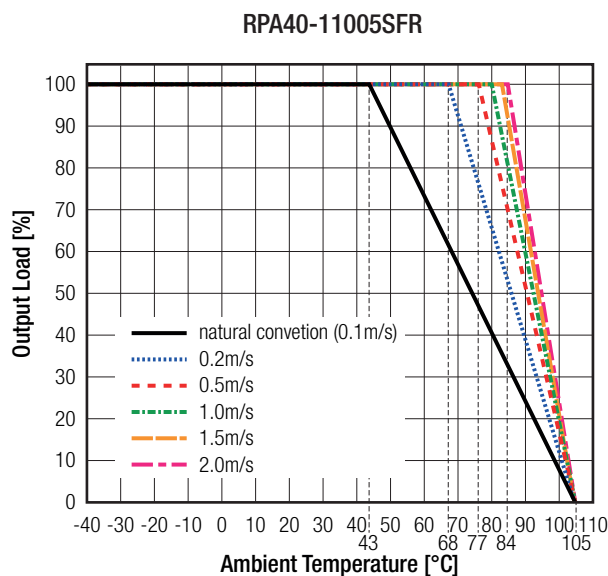
Note5: For repeat Hi-Pot testing, reduce the time and/or the test voltage

Note6: An input fuse is required if the mains supply is not over-current protected. Recommended fuse: 3.15A slow blow type

Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

ENVIRONMENTAL		
Parameter	Condition	Value
Operating Temperature Range	with derating, refer to "Derating Graph"	-40°C to $+105^\circ\text{C}$
Maximum Case Temperature		$+105^\circ\text{C}$
Temperature Coefficient		$\pm 0.02\%/K$
Thermal Impedance		11.3K/W
Operating Altitude		5000m
Operating Humidity		5% - 95% RH
Pollution Degree		PD2
Shock		according to MIL-STD-810F
Vibration		according to MIL-STD-810F
Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behavior of materials and components		EN45545-2:2013+A1:2015
Environmental testing Part 2-1: Tests – Test A: Cold	Temperature: -40°C to $+70^\circ\text{C}$, Class OT4	EN60068-2-1:2007
Environmental testing Part 2-2: Tests – Test B: Dry heat	Temperature: -40°C to $+70^\circ\text{C}$, Test cycle B, Class OT4 and ST1	EN60068-2-2:2007
Environmental testing Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	Temperature: $+55^\circ\text{C}$ and 25°C Humidity: 95% Test Duration: 48 hours	EN60068-2-30:2005
Railway applications – Rolling stock equipment – Shock and vibration tests	Functional Random vibration test Category 1 Class B Body mounted 5Hz to 2000Hz, Transverse 0.45m/s^2 , Longitudinal 0.70m/s^2 , Vertical 1.01m/s^2 Simulated long-life testing at Increased vibration test Category 1 Class B Body mounted 5Hz to 2000Hz, Transverse 2.55m/s^2 , Longitudinal 3.96m/s^2 , Vertical 5.72 Shock Test Category 1 Class A and B Body mounted Transverse 30m/s^2 (Peak), 30ms, Longitudinal 50m/s^2 (Peak), 30ms, Vertical 30m/s^2 (Peak), 30ms	EN61373:2010
MTBF	according to MIL-HDBK-217F, G.B.	1253×10^3 hours

Derating Graph
(@ chamber)



Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

SAFETY AND CERTIFICATIONS		
Certificate Type (Safety)	Report Number	Standard
Audio/video, information, and communication technology equipment. Safety requirements	221203501	IEC62368-1:2014 2nd Edition
		EN62368-1:2014+A11:2017
Audio/video, information, and communication technology equipment. Safety requirements	E196683	UL62368-1:2014 2nd Edition
		CAN/CSA-C22.2 No. 62368-1-14 2nd Edition
Railway applications - Electronic equipment used on rolling stock		EN50155:2017
RoHS2		RoHS 2011/65/EU + AM2015/863

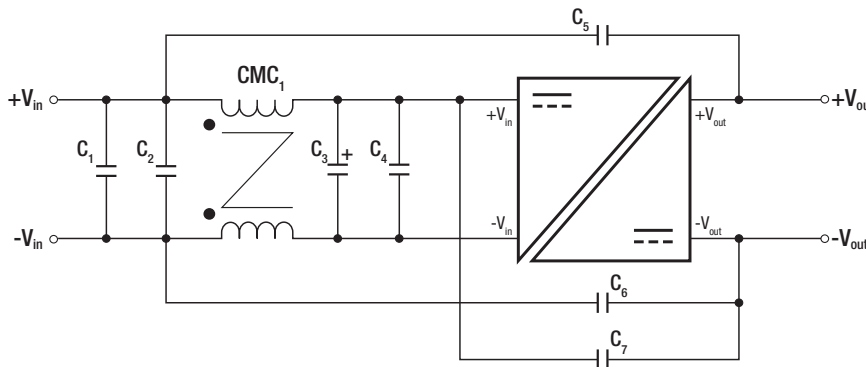
EMC Compliance according to EN50121-3-2	Condition	Standard / Criterion
Railway applications - Electromagnetic compatibility	21LE009CE50155-MB	EN50121-3-2:2016+A1:2019
ESD Electrostatic discharge immunity test	Air: ± 4 , 8kV Contact ± 4 , 6kV	EN61000-4-2, Criteria A
Radiated, radio-frequency, electromagnetic field immunity test	20V/m (80-1000MHz), 10V/m (1400-2000MHz), 5V/m (2000-2700MHz), 3V/m (5100-6000MHz)	EN61000-4-3, Criteria A
Fast Transient and Burst Immunity ⁽⁷⁾	± 2 kV	EN61000-4-4, Criteria A
Surge Immunity ⁽⁷⁾	± 05 , 1, 2kV	EN61000-4-5, Criteria A
Immunity to conducted disturbances, induced by radio-frequency fields	10Vrms (0.15-80MHz)	EN61000-4-6, Criteria A
Power frequency magnetic field	100A/m 60sec 1000A/m 1sec	EN61000-4-8, Criteria A

EMC Compliance according to EN55032/35	Condition	Standard / Criterion
Electromagnetic compatibility of multimedia equipment - emission requirements	without external components	EN55032, Class A
	refer to "EMC Filtering"	EN55032, Class B
Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments		IEC61000-6-4

Notes:

Note7: An external input filter capacitor + TVS diode is required if the module has to meet EN61000-4-4 and EN61000-4-5.
2pcs of aluminum E-cap to connect in parallel (220 μ F/200V), Recom suggest: Nippon Chemi-con KXJ series and TVS: 170V/3000W

EMC Filtering Suggestions according to EN55032



Component List Class B

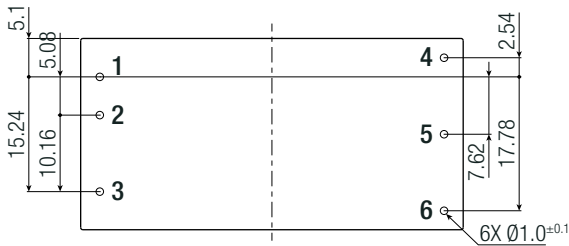
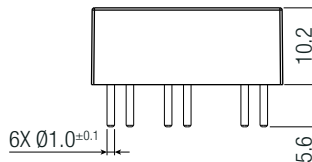
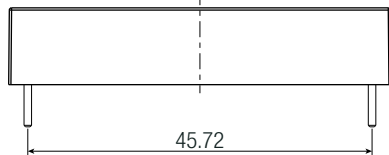
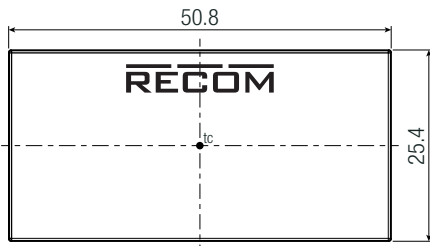
C1, C2, C4	C3	C5, C6, C7	CMC1
1 μ F/250V 1812 MLCC	47 μ F/200V, Al Cap. (lie down) Chemi-con KXJ	330pF	570 μ H

Specifications (measured @ $t_a = 25^\circ\text{C}$, nom. V_{in} , full load and after warm-up unless otherwise stated)

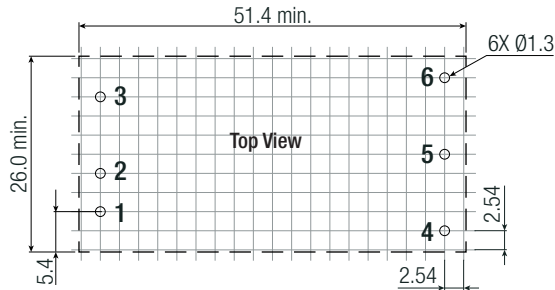
DIMENSION AND PHYSICAL CHARACTERISTICS

Parameter	Type	Value
Material	baseplate/case	black plastic (UL94 V-0)
	PCB	FR4 (UL94 V-0)
	potting	silicone (UL94 V-0)
Dimension (LxWxH)		56.4 x 36.83 x 15.0mm
Weight		32g typ.

Dimension Drawing (mm)



Recommended Footprint Details



Tolerance:
 xx.x= ±0.5mm
 xx.xx= ±0.25mm

Pinning Information

Pin #	Single	Dual
1	+Vin	+Vin
2	-Vin	-Vin
3	CTRL	CTRL
4	+Vout	+Vout
5	-Vout	COM
6	Trim	-Vout

tc= case temperature measuring point

PACKAGING INFORMATION

Parameter	Type	Value
Packaging Dimension (LxWxH)	tube	255.0 x 52.0 x 19.5mm
Packaging Quantity		9pcs
Storage Temperature Range		-55°C to +125°C
Storage Humidity	non-condensing	95% RH max.

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