

# Features

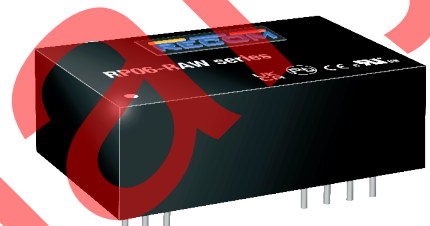
- Ultra wide 4:1 input range (36-160VDC)
- Certified for Railway applications (EN50155)
- -40°C to +105°C operating temperature with derating
- Input under voltage lockout
- Output OVLO, short circuit and OLP
- 3kVAC/1min. reinforced isolation
- Remote On/Off

# Regulated Converter

# RECOM DC/DC Converter

## RP06-RAW

**6 Watt  
DIP24  
Single and Dual  
Output**



### Description

The RP06-RAW series DC/DC converters are designed for railway rolling stock applications with an extra wide continuous input voltage range of 36-160VDC (200VDC for 1s), making them suitable for 72V, 96V and 110VDC railway systems, but they are also suitable for non-railway high voltage battery applications. They offer single or dual outputs from 3.3V up to ±15V. The high efficiency permits an ambient temperature range from -40°C to more than 85°C without derating, forced cooling, or the need for heatsinks. The RP06-RAW series features UVLO, OVP, SCP, and OLP making them ideal for any harsh railway and industrial applications such as powering IoT sensors, battery management systems, or electric fork-lift trucks. The RP06-RAW is available in an industry standard, compact DIP24 package and comes with a 3 year warranty.

### Selection Guide

Part Number	Input Voltage Range [VDC]	nom. Output Voltage [VDC]	Output Current [mA]	Efficiency typ. <sup>(1)</sup> [%]	max. Capacitive Load <sup>(2)</sup> [µF]
RP06-1103.3SRAW	36-160	3.3	1800	80	1050
RP06-11005SRAW	36-160	5	1200	81.5	750
RP06-11012SRAW	36-160	12	500	84.5	130
RP06-11015SRAW	36-160	15	400	84	100
RP06-11024SRAW	36-160	24	250	85	39
RP06-11005DRAW	36-160	±5	±600	81	±430
RP06-11012DRAW	36-160	±12	±250	85	±75
RP06-11015DRAW	36-160	±15	±200	85	±56

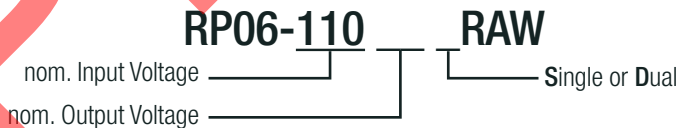
#### Notes:

- Note1: Efficiency is tested at nominal  $V_{IN}$ , full load and 25°C  
 Note2: Max. Cap load is tested at minimum input and constant resistive load



UL62368-1 certified  
 CAN/CSA-C22.2 No. 62368-1-14 certified  
 IEC/EN62368-1-1 pending  
 EN50155 compliant  
 EN50121-3-2 compliant  
 EN55032 compliant

### Model Numbering



#### Ordering Examples

RP06-1103.3SRAW	nom. $V_{IN}$ = 110VDC	nom. $V_{OUT}$ = 3.3VDC	single output
RP06-11012DRAW	nom. $V_{IN}$ = 110VDC	nom. $V_{OUT}$ = ±12VDC	dual output

**Specifications** (measured @  $T_a = 25^\circ\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

### BASIC CHARACTERISTICS

Parameter	Condition	Min.	Typ.	Max.
Internal Input Filter				Pi-Type
Input Voltage Range	nom. $V_{in} = 110\text{VDC}$	36VDC	110VDC	160VDC
Input Surge Voltage	1s max.			200VDC
Under Voltage Lockout (UVLO)	DC-DC ON			36VDC
	DC-DC OFF	32VDC	34VDC	35.8VDC
Quiescent Current			4mA	
Output Voltage Trimming	refer to "OUTPUT VOLTAGE TRIMMING"	others	-10%	+10%
		nom. $V_{out} = 15/24\text{VDC}$	-10%	+20%
Minimum Load		0%		
Start-up Time	constant resistive load	Power up	30ms	60ms
		CTRL ON/OFF	30ms	60ms
ON/OFF CTRL <sup>(3)</sup> refer to "ON/OFF CTRL"	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		-0.5mA		+0.5mA
Standby Current	DC-DC OFF		2.5mA	
Internal Operating Frequency		270kHz	300kHz	330kHz
Output Ripple and Noise <sup>(4)</sup>	20MHz BW	nom. $V_{out} = 3.3/5\text{VDC}$	50mVp-p	
		nom. $V_{out} = 12/15\text{VDC}$	75mVp-p	
		nom. $V_{out} = 24\text{VDC}$	75mVp-p	

#### Notes:

Note3: The ON/OFF control function is positive logic. The pin voltage is referenced to -Vin pin

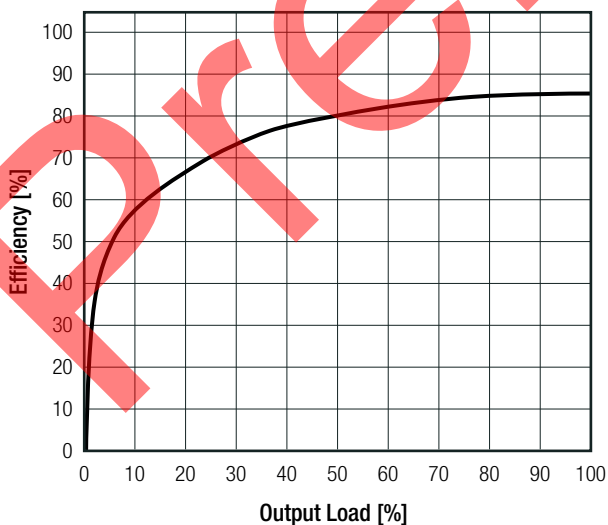
Note4: Measured with: nom.  $V_{out} = 3.3/5/12/15\text{VDC} = 10\mu\text{F}/25\text{V X7R MLCC}$

nom.  $V_{out} = 24\text{VDC} = 4.7\mu\text{F}/50\text{V X7R MLCC}$

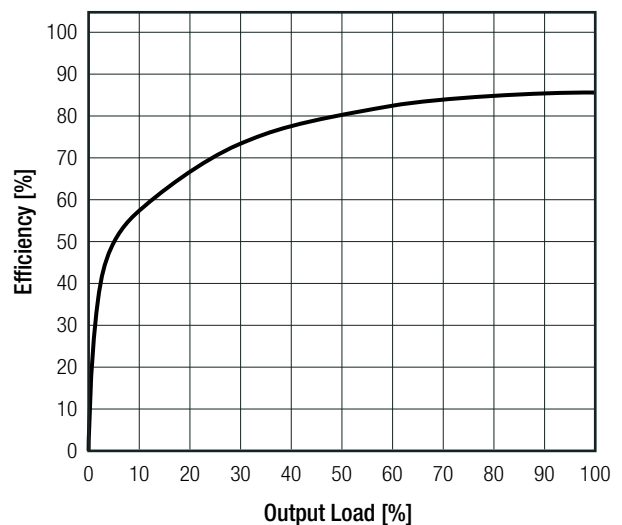
#### Efficiency vs. Load

(@ nom.  $V_{in} = 110\text{VDC}$ )

RP06-1103.3SRAW



RP06-11005SRAW

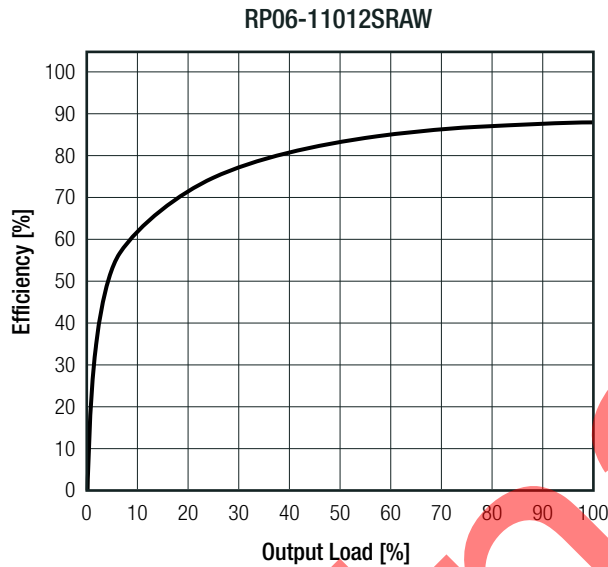


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Specifications (measured @  $T_{amb}=25^{\circ}\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

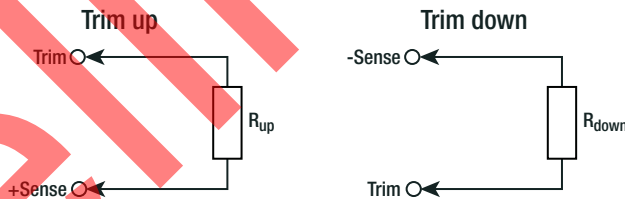
### Efficiency vs. Load

(@ nom.  $V_{in}=110\text{VDC}$ )



### OUTPUT VOLTAGE TRIMMING

RP06-RAW converter 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.



- $V_{out\_nom}$  = nominal output voltage [VDC]
- $V_{out\_set}$  = output voltage change [VDC]
- $V_{ref}$  = reference voltage [VDC]
- $R_{up}$  = trim up resistor [ $\Omega$ ]
- $R_{down}$  = trim down resistor [ $\Omega$ ]
- $R_1, R_2, R_3$  = internal resistors [ $\Omega$ ]

#### Calculation:

$$R_{up} = \frac{(R_1 \times V_{ref})}{(V_{out\_set} - V_{ref} - R_3)} - R_2$$

$$R_{down} = \frac{(V_{out\_set} - V_{ref}) \times R_1}{(V_{out\_nom} - V_{out\_set})} - R_2$$

#### Single Output

$V_{out\_nom}$	$R_1$ [ $\Omega$ ]	$R_2$ [ $\Omega$ ]	$R_3$ [ $\Omega$ ]	$V_{ref}$ [VDC]
3.3VDC	5110	2050	0.8	2.5
5VDC			2.5	
12VDC	10000	5110	9.5	
15VDC			12.5	
24VDC	56000	13000	21.5	

#### Dual Output

$V_{out\_nom}$	$R_1$ [ $\Omega$ ]	$R_2$ [ $\Omega$ ]	$R_3$ [ $\Omega$ ]	$V_{ref}$ [VDC]
5VDC	3000	3000	7.5	2.5
12VDC	56000	13000	21.5	
15VDC	30000	13000	27.5	

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**Specifications** (measured @  $T_{amb}=25^{\circ}\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

**OUTPUT VOLTAGE TRIMMING**

**Practical Example RP06-1103.3SRAW trim up +1%**

$V_{out,nom} = 3.3\text{V}$ ,  $V_{out,set} = +1\%$  (3.333VDC)

$$R_{up} = \frac{(5110 \times 2.5)}{(3.333 - 2.5 - 0.8)} - 2050 = 385071\Omega$$

$R_{up}$  according to E96  $\approx$  **383k $\Omega$**

**Practical Example RP06-11015SRAW trim down -8%**

$V_{out,nom} = 15\text{V}$ ,  $V_{out,set} = -8\%$  (13.8VDC)

$$R_{down} = \frac{(13.8 - 2.5) \times 10000}{(15 - 13.8)} - 5110 = 89057\Omega$$

$R_{down}$  according to E96  $\approx$  **88k $\Omega$**

**RP06-1103.3SRAW**

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	3.333	3.366	3.399	3.432	3.465	3.498	3.531	3.564	3.597	3.63	[VDC]
$R_{up}$ (E96) $\approx$	383k	191k	127k	95k3	75k	61k9	53k6	46k4	41k2	36k5	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	3.267	3.234	3.201	3.168	3.135	3.102	3.069	3.036	3.003	2.97	[VDC]
$R_{up}$ (E96) $\approx$	118k	54k9	34k	23k7	17k4	13k3	10k5	8k25	6k65	5k23	[ $\Omega$ ]

**RP06-11005SRAW**

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	5.05	5.10	5.15	5.20	5.25	5.30	5.35	5.4	5.45	5.50	[VDC]
$R_{up}$ (E96) $\approx$	255k	127k	82k5	61k9	48k7	40k2	34k8	30k1	26k1	23k7	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	4.95	4.90	4.85	4.80	4.75	4.70	4.65	4.60	4.55	4.50	[VDC]
$R_{up}$ (E96) $\approx$	249k	121k	78k7	56k2	44k2	35k7	29k4	24k9	21k	18k2	[ $\Omega$ ]

**RP06-11012SRAW**

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	12.12	12.24	12.36	12.48	12.60	12.72	12.84	12.96	13.08	13.20	[VDC]
$R_{up}$ (E96) $\approx$	205k	100k	64k9	47k5	36k5	29k4	24k9	21k	17k9	15k8	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	11.88	11.76	11.64	11.52	11.40	11.28	11.16	11.04	10.92	10.8	[VDC]
$R_{up}$ (E96) $\approx$	768k	383k	249k	182k	143k	118k	97k6	84k5	73k2	63k4	[ $\Omega$ ]

**RP06-11015SRAW**

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	15.15	15.3	15.45	15.60	15.75	15.90	16.05	16.20	16.35	16.50	[VDC]
$R_{up}$ (E96) $\approx$	162k	78k7	49k9	36k5	28k	22k6	1k87	15k8	13k3	11k5	[ $\Omega$ ]

Trim up	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) $\approx$	10k	8k87	7k68	6k81	6k04	5k36	4k64	4k12	3k65	3k24	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out,set} =$	14.85	14.70	14.55	14.40	14.25	14.1	13.95	13.8	13.65	13.5	[VDC]
$R_{up}$ (E96) $\approx$	825k	402k	261k	191k	150k	124k	105	88k7	76k8	68k1	[ $\Omega$ ]

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Specifications (measured @  $T_{amb}=25^{\circ}\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

### OUTPUT VOLTAGE TRIMMING

#### RP06-11024SRAW

Trim up	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]
$R_{up} (E96) \approx$	576k	280k	182k	133k	105k	84k5	69k8	60k4	52k3	45k3	[ $\Omega$ ]

Trim up	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]
$R_{up} (E96) \approx$	40k2	35k7	31k6	28k7	26k1	23k7	21k5	19k6	17k9	16k2	[ $\Omega$ ]

Trim down	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]
$R_{up} (E96) \approx$	4990k	2430k	1620k	1180k	931k	768k	649k	562k	487k	432k	[ $\Omega$ ]

#### RP06-11005DRAW

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 5.05$	$\pm 5.10$	$\pm 5.15$	$\pm 5.20$	$\pm 5.25$	$\pm 5.30$	$\pm 5.35$	$\pm 5.4$	$\pm 5.45$	$\pm 5.50$	[VDC]
$R_{up} (E96) \approx$	71k5	34k8	22k1	15k8	12k1	95k3	7k68	6k34	5k36	4k53	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 4.95$	$\pm 4.90$	$\pm 4.85$	$\pm 4.80$	$\pm 4.75$	$\pm 4.70$	$\pm 4.65$	$\pm 4.60$	$\pm 4.55$	$\pm 4.50$	[VDC]
$R_{up} (E96) \approx$	221k	107k	69k8	49k9	39k2	31k6	26k1	22k1	19k1	16k5	[ $\Omega$ ]

#### RP06-11012DRAW

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 12.12$	$\pm 12.24$	$\pm 12.36$	$\pm 12.48$	$\pm 12.60$	$\pm 12.72$	$\pm 12.84$	$\pm 12.96$	$\pm 13.08$	$\pm 13.20$	[VDC]
$R_{up} (E96) \approx$	576k	280k	182k	133k	105k	84k5	69k8	60k4	52k3	45k3	[ $\Omega$ ]

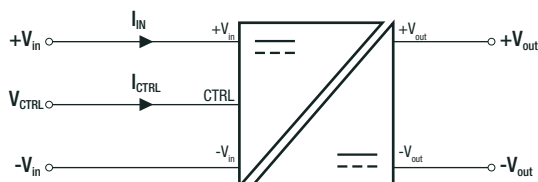
Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 11.88$	$\pm 11.76$	$\pm 11.64$	$\pm 11.52$	$\pm 11.40$	$\pm 11.28$	$\pm 11.16$	$\pm 11.04$	$\pm 10.92$	$\pm 10.8$	[VDC]
$R_{up} (E96) \approx$	4990k	2430k	1620k	1180k	931k	768k	649k	562k	487k	432k	[ $\Omega$ ]

#### RP06-11015DRAW

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 15.15$	$\pm 15.3$	$\pm 15.45$	$\pm 15.60$	$\pm 15.75$	$\pm 15.90$	$\pm 16.05$	$\pm 16.20$	$\pm 16.35$	$\pm 16.50$	[VDC]
$R_{up} (E96) \approx$	237k	113k	69k8	49k9	37k4	28k7	22k6	18k2	14k7	12k1	[ $\Omega$ ]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out\_set} =$	$\pm 14.85$	$\pm 14.70$	$\pm 14.55$	$\pm 14.40$	$\pm 14.25$	$\pm 14.1$	$\pm 13.95$	$\pm 13.8$	$\pm 13.65$	$\pm 13.5$	[VDC]
$R_{up} (E96) \approx$	2740k	1330k	866k	649k	511k	412k	348k	301k	261k	232k	[ $\Omega$ ]

### ON/OFF CTRL



#### Positive Logic

DC-DC ON	Open or $3\text{VDC} < V_{CTRL} < 12\text{VDC}$
DC-DC OFF	Open or $0\text{VDC} < V_{CTRL} < 1.2\text{VDC}$

**Specifications** (measured @  $T_{amb}=25^{\circ}\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

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	$\pm 0.2\%$
		Dual	$\pm 1.0\%$
Cross Regulation	asymmetrical 25%-100% load		$\pm 5.0\%$
Transient Response Recovery Time	25% load step change		250 $\mu\text{s}$ typ.

PROTECTIONS				
Parameter	Condition		Value	
Short Circuit Protection (SCP)			continuous, automatic recovery	
Over Voltage Protection (OVP)	zener diode clamp	Single	nom. $V_{out}=3.3\text{VDC}$	3.7-5VDC
			nom. $V_{out}=5\text{VDC}$	5.6-7VDC
			nom. $V_{out}=12\text{VDC}$	13.5-16VDC
			nom. $V_{out}=15\text{VDC}$	18.3-22VDC
			nom. $V_{out}=24\text{VDC}$	29.1-34.5VDC
		Dual	nom. $V_{out}=\pm 5\text{VDC}$	5.6-7VDC
			nom. $V_{out}=\pm 12\text{VDC}$	13.5-18.2VDC
		nom. $V_{out}=\pm 15\text{VDC}$	17-22VDC	
Over Load Protection (OLP)	% of $I_{out}$ rated; Hiccup mode		150% typ.	
Isolation Voltage <sup>(6)</sup>	I/P to O/P	1 minute	3kVAC	
Isolation Resistance	$V_{SO}=500\text{VDC}$		1G $\Omega$ min.	
Isolation Capacitance			1000pF max.	
Insulation Grade			reinforced	
<b>Notes:</b>				
Note4: This power module is not internally fused. An input line fuse must always be used. Recom suggests: nom. $V_{in}=110\text{VDC} = T0.5\text{A}$ slow blow				
Note5: For repeat Hi-Pot testing, reduce the time and/or the test voltage				

ENVIRONMENTAL		
Parameter	Condition	Value
Operating Temperature Range	with derating (refer to "Derating Graph")	$-40^{\circ}\text{C}$ to $+105^{\circ}\text{C}$
Maximum Case Temperature	no load	$+105^{\circ}\text{C}$
Temperature Coefficient		$\pm 0.02\%/K$
Thermal Impedance	@ natural convection 0.1m/s	18.91K/W typ.
Operating Humidity		5% - 95% RH max.
Pollution Degree (PD)		PD2
Shock		according to MIL-STD-810F
Thermal Shock		according to EN61373, MIL-STD-810F
Vibration		according to EN61373, MIL-STD-810F
Environmental testing Part 2-1: Tests – Test A: Cold	Low temperature start-up test Class OT4: $-40^{\circ}\text{C}$ to $+70^{\circ}\text{C}$	according to EN60068-2-1:2007
Environmental testing Part 2-2: Tests – Test B: Dry heat	Dry Heat Test Class OT4: $-40^{\circ}\text{C}$ to $+70^{\circ}\text{C}$ Class ST1: Test cycle B	according to EN60068-2-2:2007

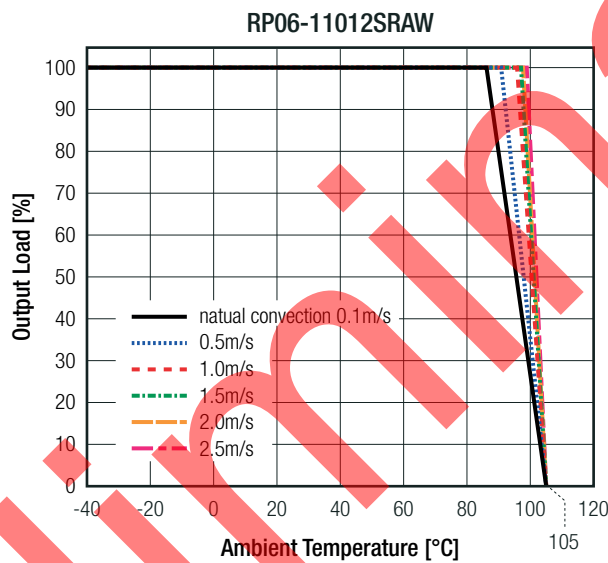
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**Specifications** (measured @  $T_{amb}=25^{\circ}\text{C}$ , nom.  $V_{in}$ , full load unless otherwise stated)

ENVIRONMENTAL		
Parameter	Condition	Value
Environmental testing Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	Damp Heat Test Temperature: +25 to +55°C Humidity: 95% ±5% RH Test Duration: 48 hours	according to EN60068-2-30:2005
Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behavior of materials and components		EN45545-2
Railway applications – Rolling stock equipment – Shock and vibration tests		EN61373:2010
MTBF	according to MIL-HDBK-217F, G.B	3036 x 10 <sup>3</sup> hours

**Derating Graph**

(@ Chamber and natural convection 0.1 m/s)



SAFETY AND CERTIFICATIONS		
Certificate Type (Safety)	Condition	Standard
Audio/video, information, and communication technology equipment. Safety requirements (CB)	pending	IEC62368-1:2014 2nd Edition
Audio/video, information, and communication technology equipment. Safety requirements (LVD)		EN62368-1:2014+A11:2017
Audio/video, information, and communication technology equipment. Safety requirements	E196683	UL62368-1:2014 2nd Edition
Railway applications - Electronic equipment used on rolling stock		CAN/CSA-C22.2 No. 62368-1-14 2nd Edition
RoHS2		EN50155:2017 RoHS 2011/65/EU + AM2015/863
EMC Compliance according to EN50121-3-2		
Condition	Standard / Criterion	
Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	without external components	EN50121-3-2
ESD Electrostatic discharge immunity test	Air: ± 8kV; Contact ±6kV	EN61000-4-2, Criteria A
Radiated, radio-frequency, electromagnetic field immunity test	20V/m	EN61000-4-3, Criteria A
Fast Transient and Burst Immunity <sup>(6)</sup>	±2kV	EN61000-4-4, Criteria A
Surge Immunity <sup>(6)</sup>	±2kV	EN61000-4-5, Criteria A
Immunity to conducted disturbances, induced by radio-frequency fields	10Vrms	EN61000-4-6, Criteria A
Power frequency magnetic field	100A/m cont.; 1000A/m 1sec	EN61000-4-8, Criteria A

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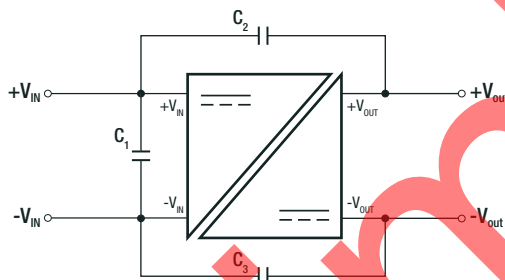
**Specifications** (measured @  $T_{amb}=25^{\circ}C$ , nom.  $V_{in}$ , full load unless otherwise stated)

SAFETY AND CERTIFICATIONS		
EMC Compliance according to EN55032/35	Condition	Standard / Criterion
Electromagnetic Compatibility of Multimedia Equipment - Emission Requirements	without external components	EN55032, Class A
	refer to <b>"EMC Filtering"</b>	EN55032, Class B
Electromagnetic compatibility of multimedia equipment – Immunity requirements		EN55035:2017
ESD Electrostatic discharge immunity test	Air: $\pm 8kV$ ; Contact $\pm 6kV$	EN61000-4-2, Criteria A
Radiated, radio-frequency, electromagnetic field immunity test	20V/m	EN61000-4-3, Criteria A
Fast Transient and Burst Immunity <sup>(6)</sup>	$\pm 2kV$	EN61000-4-4, Criteria A
Surge Immunity <sup>(6)</sup>	$\pm 2kV$	EN61000-4-5, Criteria A
Immunity to conducted disturbances, induced by radio-frequency fields	10Vrms	EN61000-4-6, Criteria A
Power frequency magnetic field	100A/m cont.; 1000A/m 1sec	EN61000-4-8, Criteria A

**Notes:**

Note6: 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 $\mu$ F/200V), Recom suggest: Nippon Chemi-con KXJ series and TVS: 220V/600W

**EMC Filtering Suggestions according to EN55032/35**



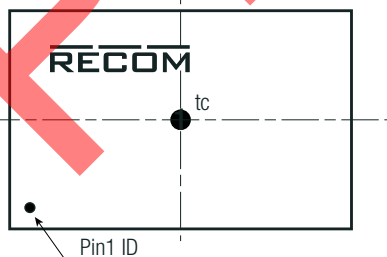
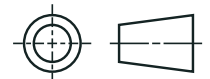
**Component List Class B**

C1	C2	C3
1 $\mu$ F	330pF	680pF

**DIMENSIONS AND PHYSICAL CHARACTERISTICS**

Parameter	Type	Value
Material	case/baseplate	non-conductive black plastic
	potting	silicone, (UL94 V-0)
Dimensions (LxWxH)		31.8 x 20.3 x 10.6mm
Weight		14g typ.

**Dimension Drawing (mm)**

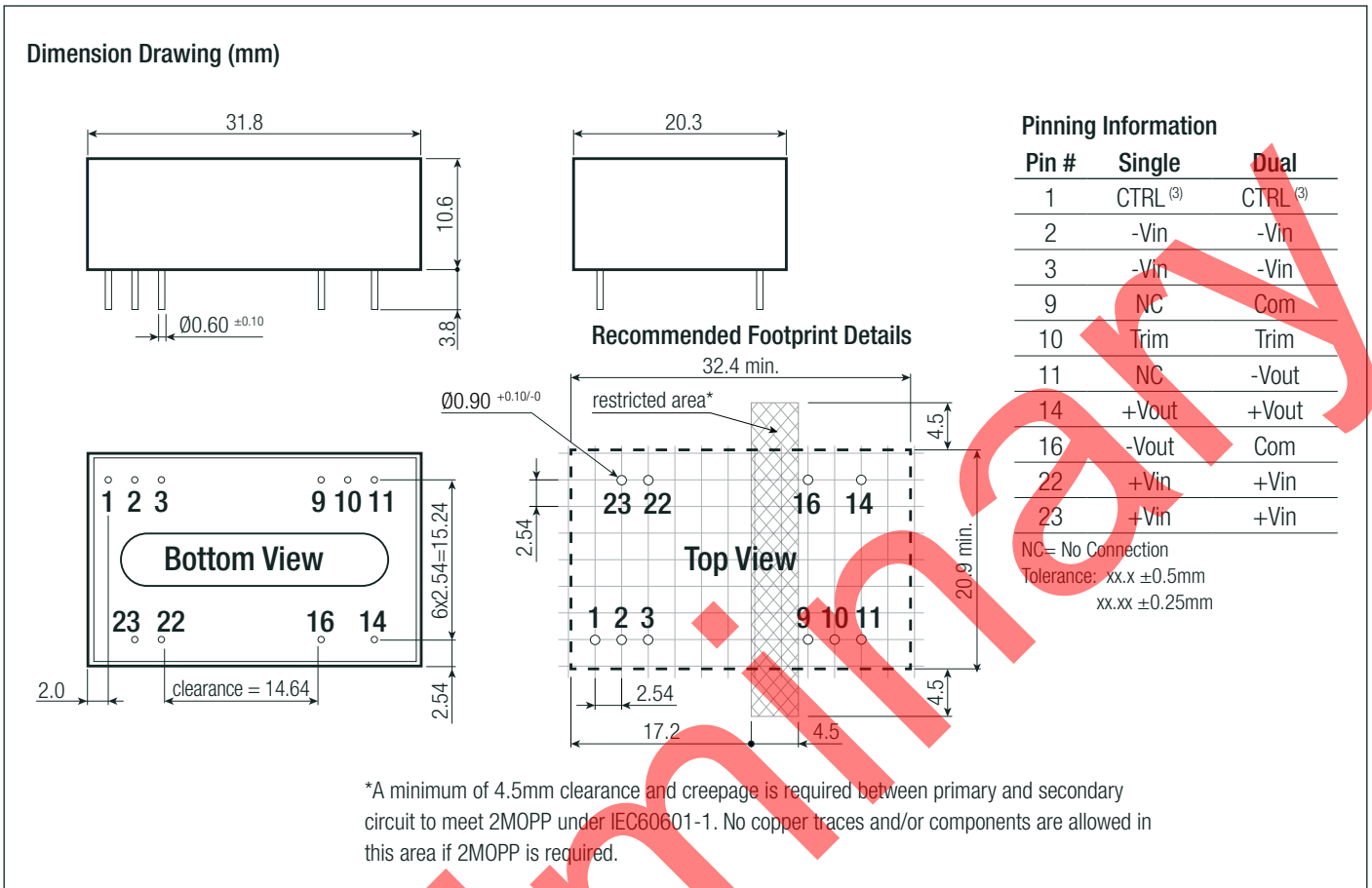


Tolerance: xx.x  $\pm$ 0.5mm  
xx.xx  $\pm$ 0.25mm

continued on next page



### Specifications (measured @ $T_{amb}=25^{\circ}\text{C}$ , nom. $V_{in}$ , full load unless otherwise stated)



### PACKAGING INFORMATION

Parameter	Type	Value
Packaging Dimension (LxWxH)	tube	255.0 x 21.8 x 16.5mm
Packaging Quantity		7pcs
Storage Temperature Range		-55°C to +125°C
Storage Humidity	non-condensing	5% - 95% RH