Features

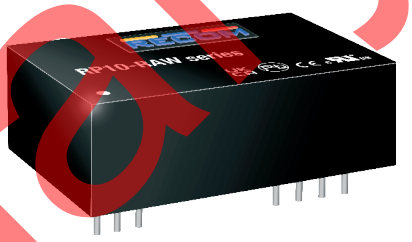
Regulated Converter

- 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

RECOM
DC/DC Converter

RP10-RAW

10 Watt DIP24 Single and Dual Output



Description

The RP10-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 75°C without derating, forced cooling, or the need for heatsinks. The RP10-RAW series features UVLO, OVP, SCP, and OLP making them ideal for many harsh railway and industrial applications such as powering IoT sensors, battery management systems, or electric fork-lift trucks. The RP10-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. (1) [%]	max. Capacitive Load (2) [µF]
RP10-1103.3SRAW	36-160	3.3	2500	83	3000
RP10-11005SRAW	36-160	5	2000	87	2500
RP10-1105.1SRAW	36-160	5.1	2000	87	2500
RP10-11012SRAW	36-160	12	830	87.5	430
RP10-11015SRAW	36-160	15	670	88	350
RP10-11024SRAW	36-160	24	416	87.5	125
RP10-11005DRAW	36-160	±5	±1000	84	±1440
RP10-11012DRAW	36-160	±12	±416	87	±250
RP10-11015DRAW	36-160	±15	±333	87	±180

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

E196683

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

RP10-110 _ _ RAW

- 110: nom. Input Voltage
- _: nom. Output Voltage
- RAW: Single or Dual

Ordering Examples

RP10-1103.3SRAW	nom. V_{IN}= 110VDC	nom. V_{OUT}= 3.3VDC	single output
RP10-11012DRAW	nom. V_{IN}= 110VDC	nom. V_{OUT}= ±12VDC	dual output

Specifications (measured @ Ta= 25°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}= 110VDC		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				6mA	
Output Voltage Trimming	refer to ***"OUTPUT VOLTAGE TRIMMING"***	others	-10%		+10%
		nom. V_{OUT}= 15/24VDC	-10%		+20%
Minimum Load			0%		
Start-up Time	constant resistive load	Power up		30ms	60ms
		CTRL ON/OFF		30ms	60ms
ON/OFF CTRL (3) refer to ***"ON/OFF CTRL"***	DC-DC ON			Open or 3VDC < V_{CTRL}< 12VDC	
	DC-DC OFF			Short or 0VDC < V_{CTRL}< 1.2VDC	
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 (4)	20MHz BW	nom. V_{OUT}= 3.3/5VDC		50mVp-p	
		nom. V_{OUT}= 12/15VDC		75mVp-p	
		nom. V_{OUT}= 24VDC		75mVp-p	

Notes:

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

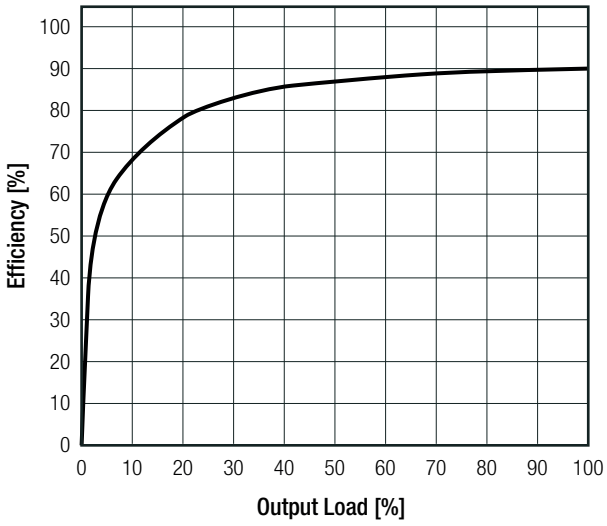
Note4: Measured with: nom. V_{OUT}= 3.3/5/5.1/12/15VDC= 10µF/25V X7R MLCC
nom. V_{OUT}= 24VDC= 4.7µF/50V X7R MLCC

Efficiency vs. Load

(@ nom. V_{IN}= 110VDC)

RP10-11005SRAW

RP10-11012SRAW



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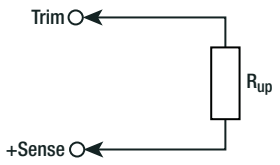
Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

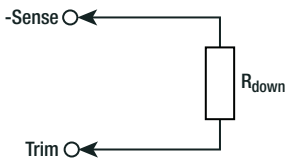
OUTPUT VOLTAGE TRIMMING

RP10-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.

Trim up



Trim down



$Vout_{nom}$	= nominal output voltage	[VDC]
$Vout_{set}$	= output voltage change	[VDC]
V_{ref}	= reference voltage	[VDC]
R_{up}	= trim up resistor	[Ω]
R_{down}	= trim down resistor	[Ω]
R_1, R_2, R_3	= internal resistors	[Ω]

Single Output

$Vout_{nom}$	R_1 [Ω]	R_2 [Ω]	R_3 [Ω]	V_{ref} [VDC]
3.3VDC	5110	2050	0.8	2.5
5VDC			2.5	
5.1VDC			2.6	
12VDC	10000	5110	9.5	
15VDC			12.5	
24VDC	56000	13000	21.5	

Dual Output

$Vout_{nom}$	R_1 [Ω]	R_2 [Ω]	R_3 [Ω]	V_{ref} [VDC]
5VDC	3000	3000	7.5	2.5
12VDC	56000	13000	21.5	
15VDC	30000	13000	27.5	

Calculation:

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

$$R_{down} = \frac{(Vout_{set} - V_{ref}) \times R_1}{(Vout_{nom} - Vout_{set})} - R_2$$

Practical Example RP10-1103.3SRAW trim up +1%

$Vout_{nom}$= 3.3V, $Vout_{set}$= +1% (3.333VDC)

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

R_{up} according to E96 ≈ **383kΩ**

Practical Example RP10-11015SRAW trim down -8%

$Vout_{nom}$= 15V, $Vout_{set}$= -8% (13.8VDC)

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

R_{down} according to E96 ≈ **88k7Ω**

RP10-1103.3SRAW

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

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

RP10-11005SRAW

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

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

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Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

OUTPUT VOLTAGE TRIMMING

RP10-1105.1SRAW

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	5.151	5.202	5.253	5.304	5.355	5.406	5.457	5.508	5.559	5.610	[VDC]
R_{up} (E96) ≈	249k	124k	806k	604k	475k	392k	34k	29k4	25k5	23k2	[Ω]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	5.049	4.998	4.947	4.869	4.845	4.794	4.743	4.692	4.641	4.590	[VDC]
R_{up} (E96) ≈	255k	124k	80k6	57k6	45k3	36k5	30k1	25k5	21k5	18k7	[Ω]

RP10-11012SRAW

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

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

RP10-11015SRAW

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

Trim up	11	12	13	14	15	16	17	18	19	20	[%]
$Vout_{set}$ =	16.650	16.800	16.950	17.100	17.250	17.400	17.550	17.700	17.850	18.000	[VDC]
R_{up} (E96) ≈	10k	8k87	7k68	6k81	6k04	5k36	4k64	4k12	3k65	3k24	[Ω]

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

RP10-11024SRAW

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	24.240	24.480	24.720	24.960	25.200	25.440	25.680	25.920	26.160	26.400	[VDC]
R_{up} (E96) ≈	576k	280k	182k	133k	105k	84k5	69k8	60k4	52k3	45k3	[Ω]

Trim up	11	12	13	14	15	16	17	18	19	20	[%]
$Vout_{set}$ =	26.640	26.880	27.120	27.360	27.600	27.840	28.080	28.320	28.560	28.800	[VDC]
R_{up} (E96) ≈	40k2	35k7	31k6	28k7	26k1	23k7	21k5	19k6	17k9	16k2	[Ω]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	23.760	23.520	23.280	23.040	22.800	22.560	22.320	22.080	21.840	21.600	[VDC]
R_{up} (E96) ≈	4990k	2430k	1620k	1180k	931k	768k	649k	562k	487k	432k	[Ω]

RP10-11005DRAW

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

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

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Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

OUTPUT VOLTAGE TRIMMING

RP10-11012DRAW

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

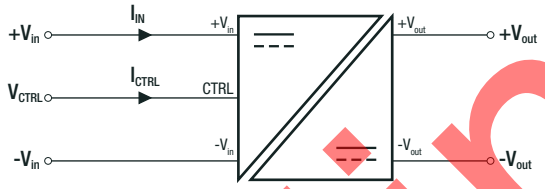
Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	±11.88	±11.76	±11.64	±11.52	±11.40	±11.28	±11.16	±11.04	±10.92	±10.8	[VDC]
R_{up} (E96) ≈	4990k	2430k	1620k	1180k	931k	768k	649k	562k	487k	432k	[Ω]

RP10-11015DRAW

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

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$Vout_{set}$ =	±14.85	±14.70	±14.55	±14.40	±14.25	±14.1	±13.95	±13.8	±13.65	±13.5	[VDC]
R_{up} (E96) ≈	2740k	1330k	866k	649k	511k	412k	348k	301k	261k	232k	[Ω]

ON/OFF CTRL



Positive Logic	DC-DC ON	Open or 3VDC<VCTRL<12VDC
	DC-DC OFF	Open or 0VDC<VCTRL<1.2VDC

REGULATIONS

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

PROTECTIONS

Parameter	Condition			Value
Short Circuit Protection (SCP)				continuous, automatic recovery
Over Voltage Protection (OVP)	zener diode clamp	Single	nom. V_{OUT}= 3.3VDC	3.7-5VDC
			nom. V_{OUT}= 5/5.1VDC	6-7VDC
			nom. V_{OUT}= 12VDC	13.5-16VDC
			nom. V_{OUT}= 15VDC	18.3-22VDC
			nom. V_{OUT}= 24VDC	29.1-34.5VDC
		Dual	nom. V_{OUT}= ±5VDC	5.6-7VDC
			nom. V_{OUT}= ±12VDC	13.5-18.2VDC
			nom. V_{OUT}= ±15VDC	17-22VDC

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Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

Parameter	Condition		Value
Over Load Protection (OLP)	% of Iout rated; Hiccup mode		150% max.
Isolation Voltage (5)	I/P to O/P	1 minute	3kVAC
Isolation Resistance	V_{ISO}= 500VDC		1GΩ min.
Isolation Capacitance			1000pF max.
Insulation Grade			reinforced

Notes:

Note4: This power module is not internally fused. An input line fuse must always be used. Recom suggests: nom. V_{IN}= 110VDC = T0.63A slow blow

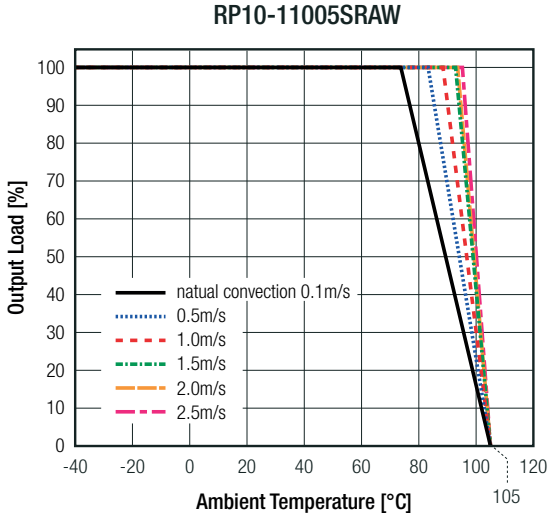
Note5: For repeat Hi-Pot testing, reduce the time and/or the test voltage

ENVIRONMENTAL

Parameter	Condition	Value
Operating Temperature Range	with derating (refer to ***"Derating Graph"***)	-40°C to +105°C
Maximum Case Temperature	no load	+105°C
Temperature Coefficient		±0.02%/K
Thermal Impedance	@ natural convection 0.1m/s	18.31K/W
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°C to +70°C	according to EN60068-2-1:2007
Environmental testing Part 2-2: Tests – Test B: Dry heat	Dry Heat Test Class OT4: -40°C to +70°C Class ST1: Test cycle B	according to EN60068-2-2:2007
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	1648 x 10^3 hours

Derating Graph

(@ Chamber and natural convection 0.1m/s)



Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

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
		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

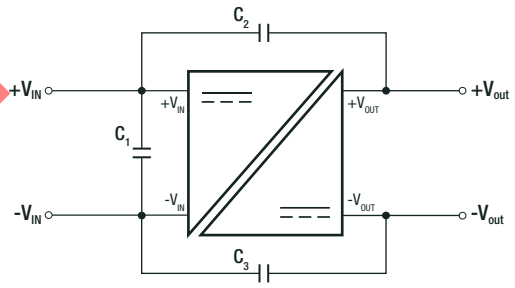
EMC Compliance according to EN50121-3-2	Condition	Standard / Criterion
Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	without external components	EN50121-3-2
ESD Electrostatic discharge immunity test	Air: ± 8,4,2kV; Contact ±6,4kV	EN61000-4-2, Criteria A
Radiated, 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 (6)	±2kV	EN61000-4-4, Criteria A
Surge Immunity (6)	±0.5, 1, 2kV	EN61000-4-5, Criteria A
Immunity to conducted disturbances, induced by radio-frequency fields	10V (0.15-80MHz)	EN61000-4-6, Criteria A
Power frequency magnetic field	100A/m 60s.; 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 of multimedia equipment – Immunity requirements		EN55035:2017
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 (6)	±2kV	EN61000-4-4, Criteria A
Surge Immunity (6)	±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 (220µF/200V), Recom suggest: Nippon Chemi-con KXJ series and TVS: 220V/600W

EMC Filtering Suggestions according to EN55032/35



Component List Class B

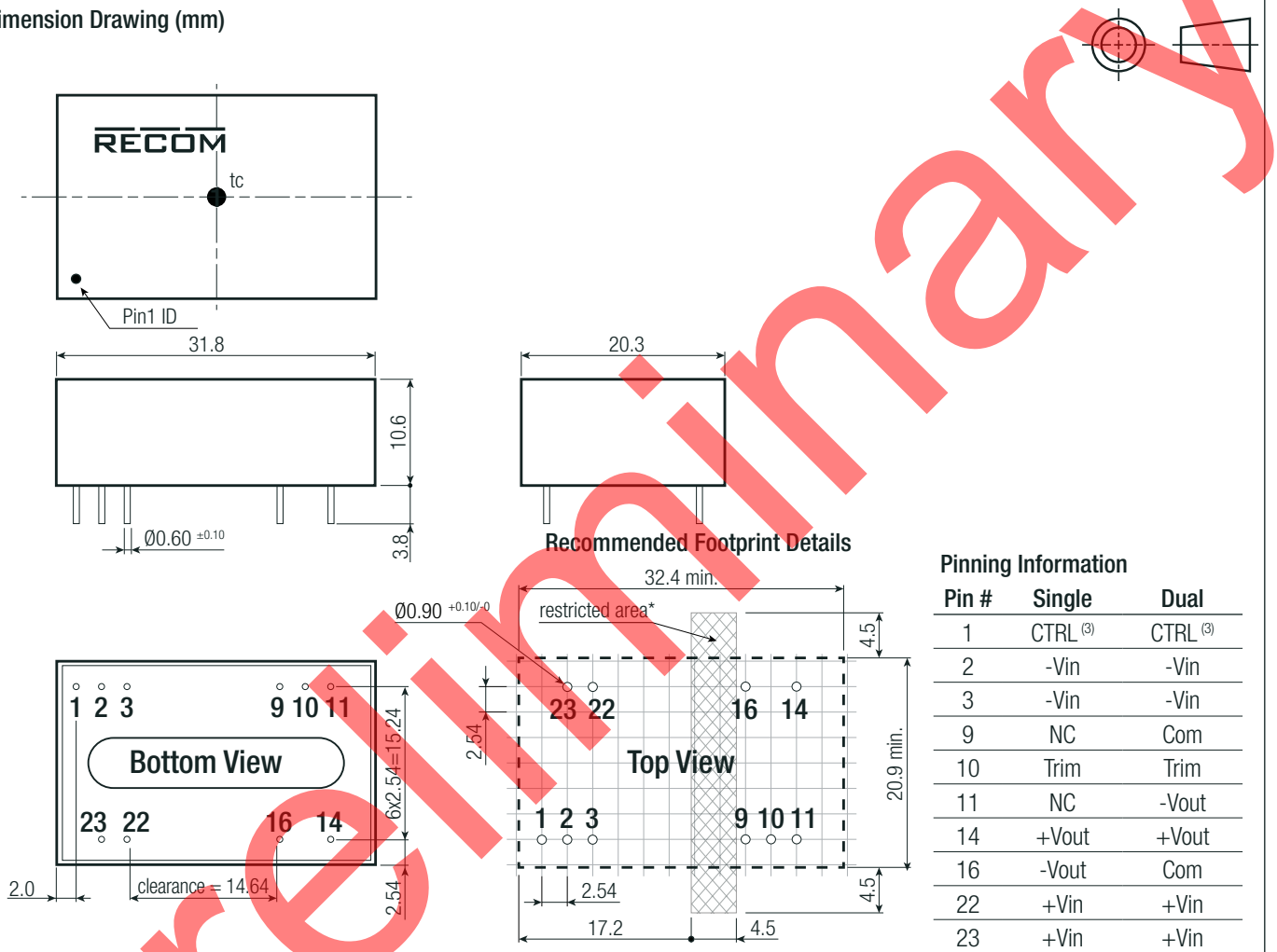
C1	C2	C3
1µF	330pF	680pF

Specifications (measured @ T_{amb}= 25°C, nom. V_{IN}, full load unless otherwise stated)

DIMENSIONS AND PHYSICAL CHARACTERISTICS

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

Dimension Drawing (mm)



*A minimum of 4.5mm clearance and creepage is required between primary and secondary circuit to meet 2MOPP under IEC60601-1. No copper traces and/or components are allowed in this area if 2MOPP is required.

Pinning Information

Pin #	Single	Dual
1	CTRL (3)	CTRL (3)
2	-Vin	-Vin
3	-Vin	-Vin
9	NC	Com
10	Trim	Trim
11	NC	-Vout
14	+Vout	+Vout
16	-Vout	Com
22	+Vin	+Vin
23	+Vin	+Vin

NC= No Connection
Tolerance: xx.x ±0.5mm
xx.xx ±0.25mm

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