

Features

- 36-185VDC input voltage range (max.)
- 3kVDC/1 minute isolation
- -40°C to +85°C ambient without derating
- EN50155 certified, EN45545-2 compliant, CE marked
- Efficiency up to 90%
- Compact 1"x1" case size

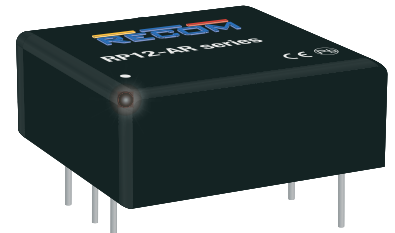
Regulated Converter

RP12-AR

12 Watt
1" x 1"



Single and Dual Output



IEC/EN60950-1 certified
EN50155 certified
EN55032 compliant

Description

The RP12-AR series DC/DC converters are designed for railway rolling stock applications with an extra wide continuous input voltage range of 36-160VDC (185VDC for 1s), making them suitable for 48V, 72V, 96V and 110VDC railway systems, but they are also suitable for non-railway high voltage battery applications. They have a built-in class A filter network and offer single or dual outputs from 3.3V up to +/-24V. The high efficiency permits an ambient temperature range from -40°C to +85°C without derating, forced cooling or the need for heatsinks. The RP12-AR series feature UVLO, OVP, SCP and OLP. This makes them ideal for many harsh railway and industrial applications such as powering IoT sensors, battery management systems or electric fork-lift trucks. The RP12-AR is available in an industry standard 1" x 1" package and comes with a 3 year warranty.

Selection Guide

Part Number	Input Voltage Range [VDC]	Output Voltage [VDC]	Output Current [mA]	Efficiency ⁽¹⁾ typ. [%]	Max. Capacitive Load ⁽²⁾ [µF]
RP12-1103.3SAR	36-160	3.3	3630	88	5200
RP12-11005SAR	36-160	5	2400	89	3600
RP12-11012SAR	36-160	12	1000	89	600
RP12-11015SAR	36-160	15	800	89	500
RP12-11024SAR	36-160	24	500	90	200
RP12-11012DAR	36-160	±12	±500	89	±360
RP12-11015DAR	36-160	±15	±400	89	±250
RP12-11024DAR	36-160	±24	±250	90	±100

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



Notes:

Note3: add suffix "P" for positive logic (1=ON, 0=OFF)
add suffix "N" instead for negative logic (0=ON, 1=OFF)
or suffix /XC for omitted CTRL pin (refer to dimension drawing)

Ordering Examples:

RP12-11005SAR/P	36-160Vin	5Vout	single output	positive logic
RP12-11012DAR/N	36-160Vin	±12Vout	dual output	negative logic
RP12-11024SAR/XC	36-160Vin	24Vout	single output	no CTRL pin

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

BASIC CHARACTERISTICS

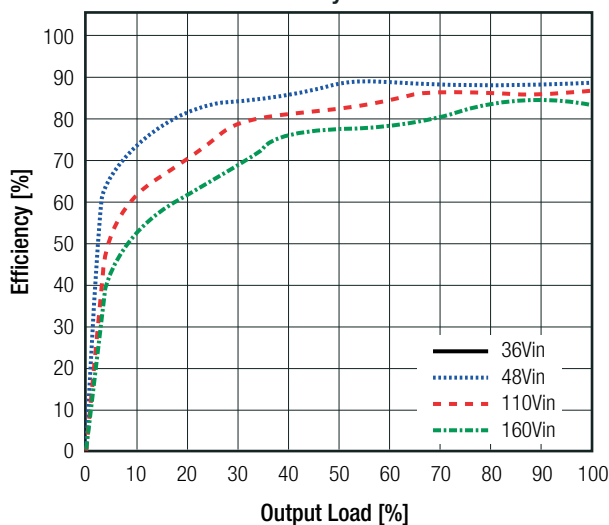
Parameter	Condition		Min.	Typ.	Max.
Internal Input Filter			Pi type		
Input Voltage Range	nom. $V_{in} = 110\text{VDC}$		36VDC	110VDC	160VDC
Input Surge Voltage	1 second max.				185VDC
Under Voltage Lockout (UVLO)	nom. $V_{in} = 110\text{VDC}$	DC-DC ON DC-DC OFF	32VDC	34VDC	35.5VDC
Input Current	nom. $V_{in} = 110\text{VDC}$				130mA
Quiescent Current	no load				8mA
Output Voltage Trimming	only for single output	15Vout, 24Vout	-10%		+20%
		others	-10%		+10%
Minimum Load			0%		
Start-up Time	Power Up and CTRL function			30ms	40ms
ON/OFF CTRL ⁽⁴⁾	Positive Logic	DC-DC ON DC-DC OFF	Open or $3\text{VDC} < V_{CTRL} < 15\text{VDC}$ Short or $0\text{V} < V_{CTRL} < 1.2\text{VDC}$		
	Negative Logic	DC-DC ON DC-DC OFF	Short or $0\text{V} < V_{CTRL} < 1.2\text{VDC}$ Open or $3\text{VDC} < V_{CTRL} < 15\text{VDC}$		
Input Current of CTRL Pin	DC-DC ON		-0.5mA		1mA
Standby Current	DC-DC OFF			2.5mA	
Internal Operating Frequency	3.3Vout, 5Vout		220kHz	245kHz	270kHz
	others		270kHz	300kHz	330kHz
Output Ripple and Noise	20MHz BW	with a 10 μF /6.3V MLCC	3.3Vout, 5Vout 12Vout, 15Vout 24Vout	75mVp-p	
		with a 1 μF /25V MLCC		100mVp-p	
		with a 2.2 μF /50V MLCC		125mVp-p	

Notes:

Note4: The pin voltage is referenced to -Vin pin

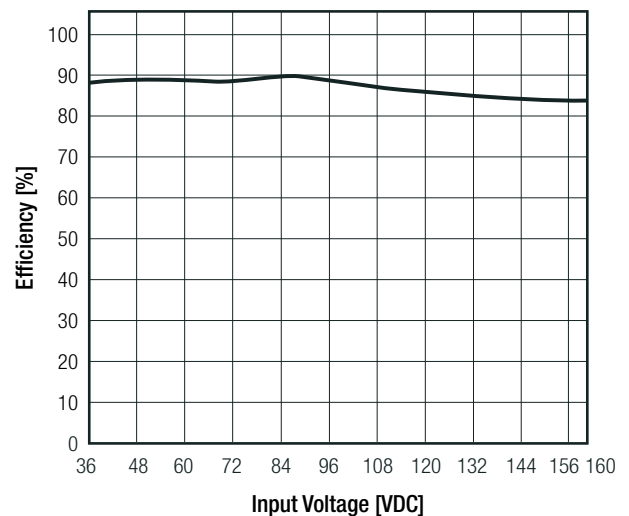
RP12-11012SAR

Efficiency vs. Load



Efficiency vs. Input Voltage

@ nom. V_{in}



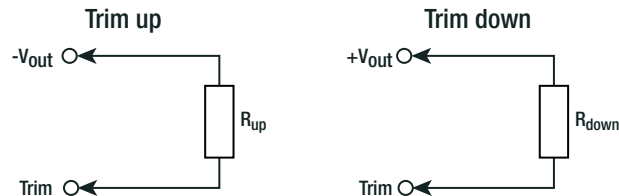
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Specifications (measured @ Ta= 25°C, nom. Vin, full load and after warm-up unless otherwise stated)

OUTPUT VOLTAGE TRIMMING

Output Voltage Trimming

It allows the user to increase or decrease the output voltage of the module. This is accomplished by connecting an external resistor between the Trim pin and either the +Vout or -Vout pins. With an external resistor between the Trim and -Vout pin, the output voltage increases. With an external resistor between the Trim and +Vout pin, the output voltage decreases. The values for trim resistors shown in trim tables below are according to standard E96 values; therefore, the specified voltage may slightly vary.



V_{out_nom} = nominal output voltage [VDC]
 V_{out_set} = trimmed output voltage [VDC]
 V_{ref} = reference voltage [VDC]
 R_{up} = trim up resistor [Ω]
 R_{down} = trim down resistor [Ω]
 R_1 & R_2 = internal resistors [Ω]
 k_u = trim up factor []

V_{out_nom}	R_1	R_2	k_u	V_{ref}
3.3VDC	5k1 Ω	2k Ω	0.8	2.5VDC
5VDC	5k1 Ω	2k Ω	2.5	
12VDC	10k Ω	5k1 Ω	9.5	
15VDC	10k Ω	5k1 Ω	12.5	
24VDC	56k Ω	13k Ω	21.5	

Calculation:

$$R_{up} = \left[\frac{R_1 \times V_{ref}}{V_{out_set} - V_{ref} - k_u} \right] - R_2$$

$$R_{down} = \left[\frac{(V_{out_set} - V_{ref}) \times R_1}{V_{out_nom} - V_{out_set}} \right] - R_2$$

Practical Example RP12-11012SAR/P +10% / -10%:

$$R_{up} = \left[\frac{10k \times 2.5}{13.2 - 2.5 - 9.5} \right] - 5k1 = 15k7\Omega$$

R_{up} according to E96 \approx **15k8 Ω**

$$R_{down} = \left[\frac{(10.8 - 2.5) \times 10k}{12 - 10.8} \right] - 5k1 = 64k1\Omega$$

R_{down} according to E96 \approx **63k4 Ω**

RP12-1103.3SAR

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	3.33	3.36	3.39	3.43	3.46	3.49	3.53	3.56	3.59	3.63	[VDC]
R_{up} (E96) \approx	383k	191k	127k	95k3	75k	61k9	53k6	46k4	41k2	36k5	[Ω]

Trim down	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_set} =$	3.26	3.23	3.20	3.16	3.13	3.10	3.06	3.03	3.00	2.97	[VDC]
R_{down} (E96) \approx	118k	54k9	34k	23k7	17k4	13k3	10k5	8k25	6k65	5k23	[Ω]

RP12-11005SAR

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	5.40	5.45	5.50	[VDC]
R_{up} (E96) \approx	255k	127k	82k5	61k9	48k7	40k2	34k8	301	26k1	23k7	[Ω]

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_{down} (E96) \approx	249k	121k	78k7	56k2	44k2	35k7	29k4	24k9	21k	18k2	[Ω]

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

RP12-11012SAR

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	10k	64k9	47k5	36k5	29k4	24k9	20k1	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 _{down} (E96) ≈	768k	383k	249k	182k	143k	118k	97k6	84k5	73k2	63k4	[Ω]

RP12-11015SAR

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
Vout _{set} =	15.15	15.30	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	18k7	15k8	13k3	11k5	[Ω]
Trim up	11	12	13	14	15	16	17	18	19	20	[%]
Vout _{set} =	16.65	16.80	16.95	17.10	17.25	17.40	17.55	17.70	17.85	18.00	[VDC]
R _{up} (E96) ≈	10k	8k8	7k6	6k8	6k	5k3	4k6	4k1	3k6	3k2	[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	14.10	13.95	13.80	13.65	13.50	[VDC]
R _{down} (E96) ≈	825K	402k	261k	191k	150k	124k	105k	88k7	76k8	68k1	[Ω]

RP12-11024SAR

Trim up	1	2	3	4	5	6	7	8	9	10	[%]
Vout _{set} =	24.24	24.48	24.72	24.96	25.2	25.44	25.68	25.92	26.16	26.40	[VDC]
R _{up} (E96) ≈	576k	280k	182k	133k	105k	84k5	69k8	95k3	52k3	45k3	[Ω]
Trim up	11	12	13	14	15	16	17	18	19	20	[%]
Vout _{set} =	26.64	26.88	27.12	27.36	27.6	27.84	28.08	28.32	28.56	28.80	[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} =	23.76	23.52	23.28	23.04	22.8	22.56	22.32	22.08	21.84	21.60	[VDC]
R _{down} (E96) ≈	4M99	2M43	1M62	1M18	931k	768k	649k	562k	487k	432k	[Ω]

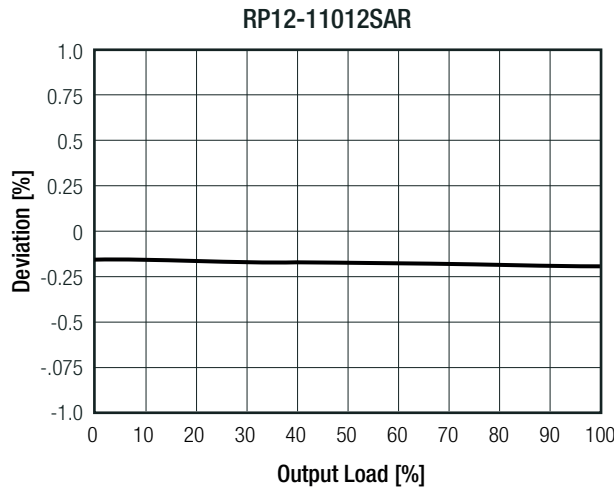
REGULATIONS

Parameter	Condition		Value
Output Accuracy			±1.0% max.
Line Regulation	low line to high line, full load	single	±0.2% max.
		dual	±0.5% max.
Load Regulation	0% to 100% load	single	±0.2% max.
		dual	±1.0% max.
Load Regulation	10% to 100% load	single	±0.1% max.
		dual	±0.8% max.
Cross Regulation	dual output only, assymetrical load 50%/100% full load		±5.0% max.
Transient Response	25% load step change recovery time		200mVp-p 250µs typ.

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

Deviation vs. Load



PROTECTIONS

Parameter	Type		Value
Short Circuit Protection (SCP)	below 100mΩ		continuous, auto recovery
Over Voltage Protection (OVP)	3.3Vout 5Vout 12Vout 15Vout 24Vout		3.7 - 5.4VDC 5.6 - 7.0VDC 13.5 - 19.6VDC latch off mode 18.3 - 22.0VDC 29.1 - 32.5VDC
Over Load Protection (OLP)			210% of rated Iout, Hiccup
Isolation Voltage ⁽⁵⁾	tested for 1 minute	I/P to O/P I/P or O/P to Case	3kVDC 1.6kVDC
Isolation Resistance	Viso= 500VDC		1GΩ min.
Isolation Capacitance			2000pF max.
Insulation Grade			functional

Notes:

Note5: Refer to local safety regulations if input over-current protection is also required. Recommended fuse: slow blow type

ENVIRONMENTAL

Parameter	Condition		Value
Operating Temperature Range ⁽⁶⁾	with derating (refer to derating graph)		-40°C to +100°C
Maximum Case Temperature			+105°C
Temperature Coefficient			±0.02%/K
Thermal Impedance	0.1m/s, vertical direction	without PCB with PCB ⁽⁶⁾	17.8K/W 12.5K/W
Operating Altitude			2000m
Operating Humidity	non-condensing		5% - 95% RH max.
Pollution Degree			PD2

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

Parameter	Condition		Value
Rolling Stock equipment - Shock and Vibration tests	Random vibration	5Hz to 150Hz Transverse: 0.45m/s ² Longitudinal: 0.7m/s ² Vertical: 1.01m/s ² Duration: 10min/axis	EN61373:2010
	Increased random vibration	5Hz to 150Hz Transverse: 2.55m/s ² Longitudinal: 3.86m/s ² Vertical: 5.72m/s ² Duration: 5h/axis	
	Shock	Transverse: 30m/s ² (Peak) Longitudinal: 506m/s ² (Peak) Vertical: 30m/s ² (Peak)	
Environmental testing Part 2-1	Test A: Cold	-40°C, 2 hours	EN60068-2-1:2007
Environmental testing Part 2-2	Test B: Dry heat	+70°C and +85°C, 6 hours	EN60068-2-2:2007
Environmental testing Part 2-30	Heat damp test	Temperature: +25 to +55°C Humidity: 95% ±5% RH Test Duration: 48 hours	EN60068-2-30:2005
Fire protection on railway vehicles Part2: Requirements for fire behaviour of materials and components			EN45545-2:2013
Fire hazard testing Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products	Oxygen index test		EN ISO 4589-2 OI
Fire hazard testing Part 11-10: Test flames – 50 W horizontal and vertical flame test methods	Glow-wire test		EN60695-2-11
MTBF	according to MIL-HDBK-217F, G.B.	+25°C	2090 x 10 ³ hours

Thermal Calculation:

$$P_{diss} = P_{out\ set} \times \left[\frac{1 - \eta}{\eta} \right]$$

$$T_{over} = R_{th} \times P_{diss}$$

$$T_{amb} = T_{case\ max.} - T_{over}$$

T_{case max.} = max. case temperature [°C]

T_{over} = temperature losses [°C]

T_{amb} = ambient temperature [°C]

P_{out nom.} = nom. output power [W]

P_{out set} = output power set [W]

η = efficiency (see graph) [%]

P_{diss} = internal losses [W]

R_{th} = thermal impedance [K/W]

Practical Example:

Take the RP12-11024SAR with 110V Input Voltage, 100% load, natural convection 0.1m/s, in vertical direction.⁽⁶⁾
What is the maximum ambient operating temperature?

Thermal Impedance		
airflow [m/s]	R _{th} w/o PCB [K/W]	R _{th} w PCB [K/W]
0.1	17.8	12.5
2	6.3	4.4

T_{case max} = 105°C

P_{out set} = 100%

R_{th} = 12.5K/W (vertical)

$$P_{diss} = 12W \times \left[\frac{1 - 0.9}{0.9} \right] = 1.33W$$

$$T_{over} = 12.5 \times 1.33 = +16.7°C$$

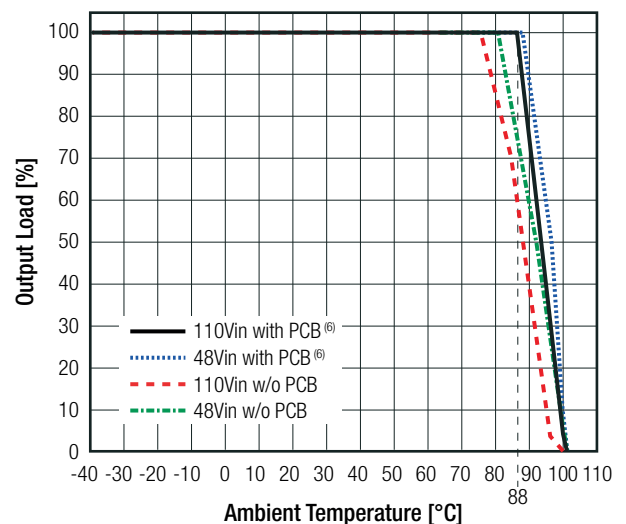
$$T_{amb} = 105 - 16.7 = +88.3°C$$

Notes:

Note6: Test PCB: Eurocard 160x100mm 105µm copper, double layer

Derating Graph

(@ Chamber with 0.1m/s natural convection)



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

SAFETY AND CERTIFICATIONS

Certificate Type (Safety)	Report / File Number	Standard
Information Technology Equipment, General Requirements for Safety (LVD)		EN60950-1:2006 + A2:2013 IEC60950-1:2005 2nd Edition + A2:2013
Railway Applications - Electronic Equipment used on Rolling Stock		EN50155:2007 + AC:2012
RoHS2+		RoHS-2011/65/EU + AM-2015/863

EMC Compliance (Industrial and Multimedia)

EMC Compliance (Industrial and Multimedia)	Condition	Standard / Criterion
Electromagnetic compatibility of multimedia equipment - Emission requirements	without external filter with external filter	EN55032:2015+AC:2016, Class A EN55032:2015+AC:2016, Class B
Information technology equipment - Immunity characteristics - Limits and methods of measurement		EN55024:2010 + A1:2015
ESD Electrostatic Discharge Immunity Test	Air: ±2, 4, 8kV and Contact: ±4, 6kV	IEC61000-4-2:2008, Criteria A EN61000-4-2:2009, Criteria A
Radiated, Radio-Frequency, Electromagnetic Field Immunity Test	10V/m (80MHz-1GHz)	IEC61000-4-3:2006 + A2:2010, Criteria A EN61000-4-3:2006 + A2:2010, Criteria A
Fast Transient and Burst Immunity ⁽⁷⁾	DC Port: ±2.0kV	EN61000-4-4:2012, Criteria A
Surge Immunity ⁽⁷⁾	DC Port: ±0.5, 1, 2.0kV	EN61000-4-5:2014, Criteria A
Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields	10V r.m.s.	IEC61000-4-6:2013, Criteria A EN61000-4-6:2014+AC:2015, Criteria A
Power Magnetic Field Immunity	50Hz, 1A/m 100A/m (1 min) 50Hz, 1000A/m (1 sec)	IEC61000-4-8:2009, Criteria A EN61000-4-8:2010, Criteria A

EMC Compliance (Railway)

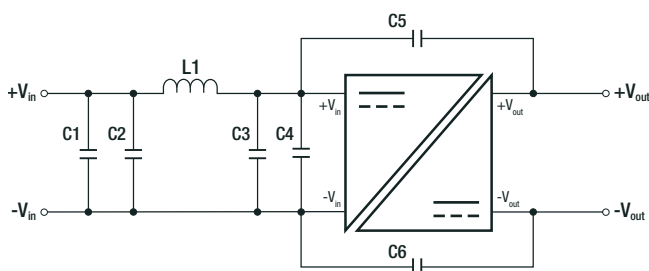
EMC Compliance (Railway)	Condition	Standard / Criterion
Railway applications - Electromagnetic compatibility		EN50121-3-2:2006
Industrial, Scientific and Medical Equipment - Radio Frequency Disturbance Characteristics - Limits and Methods of Measurement		EN55011
ESD Electrostatic Discharge Immunity Test	Air: ±2, 4, 8kV and Contact: ±4, 6kV	EN61000-4-3, Criteria A
Radiated, Radio-Frequency, Electromagnetic Field Immunity Test	10V/m (80MHz-1GHz)	EN61000-4-4, Criteria A
Fast Transient and Burst Immunity ⁽⁷⁾	DC Port: ±2.0kV	EN61000-4-5, Criteria A
Surge Immunity ⁽⁷⁾	DC Port: ±0.5, 1, 2.0kV	EN61000-4-6, Criteria A

Notes:

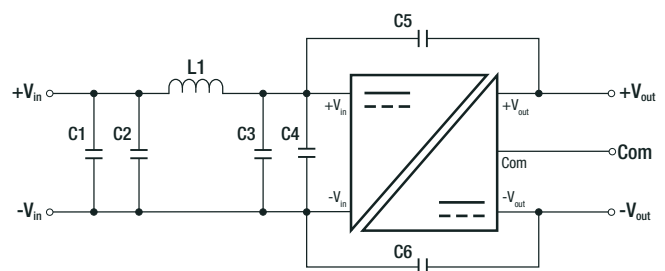
Note7: Tested with an aluminum electrolytic capacitor (Nippon chemi-con KYJ series) 150µF/200V with a TVS (SMBJ300A) 300V, 600W peak pulse power wired in parallel

EMC Filtering according to EN55032 Class B

Single Output



Dual Output



Component List

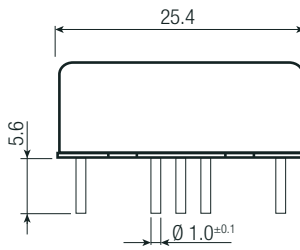
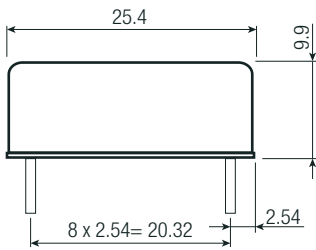
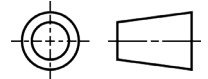
C1, C2, C3, C4	L1	C5, C6
0.68µF / 250V 1210 MLCC	22µH 1.1A SMD Inductor	1000pF / 3kV 1808 MLCC

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

DIMENSION AND PHYSICAL CHARACTERISTICS

Parameter	Type	Value
Material	case potting PCB	copper silicone, (UL94 V-0) FR4, (UL94 V-1)
Dimension (LxWxH)		25.4 x 25.4 x 9.9mm
Weight		16.5g typ.

Dimension Drawing (mm)

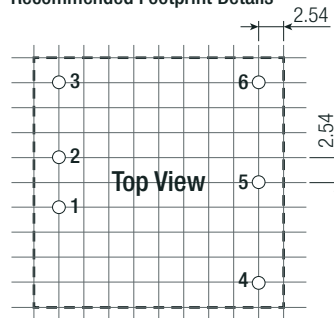
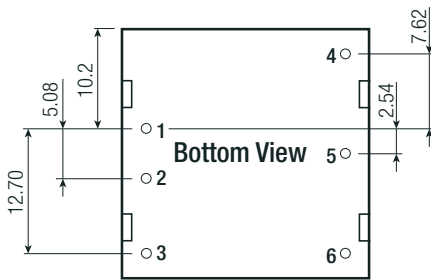


Pinning information

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

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

Recommended Footprint Details



PACKAGING INFORMATION

Parameter	Type	Value
Packaging Dimension (LxWxH)	tube	257.0 x 26.5 x 19.0mm
Packaging Quantity		8pcs
Storage Temperature Range		-55°C to +125°C
Storage Humidity	non-condensing	95% RH max.

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[ESM6D044440C05AAQ](#) [FMD15.24G](#) [PSL486-7LR](#) [Q48T30020-NBB0](#) [JAHW100Y1](#) [SPB05C-12](#) [SQ24S15033-PS0S](#) [18952](#) [19-130041](#)
[CE-1003](#) [CE-1004](#) [GQ2541-7R](#) [RDS180245](#) [MAU228](#) [J80-0041NL](#) [DFC15U48D15](#) [XGS-0512](#) [XGS-1205](#) [XGS-1212](#) [XGS-2412](#) [XGS-](#)
[2415](#) [XKS-1215](#) [06322](#) [NCT1000N040R050B](#) [SPB05B-15](#) [SPB05C-15](#) [L-DA20](#) [DCG40-5G](#) [QME48T40033-PGB0](#) [XKS-2415](#) [XKS-2412](#)
[XKS-1212](#) [XKS-1205](#) [XKS-0515](#) [XKS-0505](#) [XGS-2405](#) [XGS-1215](#) [XGS-0515](#) [PS9Z-6RM4](#) [73-551-5038I](#) [AK1601-9RT](#) [VI-N61-CM](#) [VI-](#)
[R5022-EXWW](#) [PSC128-7iR](#) [RPS8-350ATX-XE](#) [DAS1004812](#) [PQA30-D24-S24-DH](#) [VI-M5F-CQ](#) [VI-LN2-EW](#) [VI-PJW01-CZY](#)