

# Features

- Reinforced insulation for 250VAC working voltage
- Clearance and creepage distance >8.0mm
- 5kVAC I/P to O/P 2MOPP isolation
- 4.5µA maximum patient leakage current
- Industry standard pinout
- 4:1 wide input range

# Regulated Converter



## REM60-W

60 Watt

4:1 Input

2.3" x 1.5"

Single and Dual Output



### Description

The REM60-W series of medical grade regulated DC/DC converters features reinforced 5kVAC/1minute isolation with low 4.5µA leakage (B, BF and CF compatible) and are 60601-1 3rd Ed. certified for 250VAC continuous working voltage isolation. The industry standard 2.3"x1.5" package offers tightly regulated single and dual outputs which can operate down to zero load. The outputs are also short circuit and overload protected. The converters are certified to IEC/EN and ANSI/AAMI standards and carry the UL mark.

### 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]
REM60-2405SW	9-36	5	12000	89.5	17000
REM60-245.1SW	9-36	5.1	12000	89.5	17000
REM60-2412SW	9-36	12	5000	91.5	3000
REM60-2415SW	9-36	15	4000	90	1900
REM60-2424SW	9-36	24	2500	90	730
REM60-2412DW	9-36	±12	±2500	90	±1500
REM60-2415DW	9-36	±15	±2000	90	±940
REM60-4805SW	18-75	5	12000	89.5	17000
REM60-485.1SW	18-75	5.1	12000	89.5	17000
REM60-4812SW	18-75	12	5000	92	3000
REM60-4815SW	18-75	15	4000	95.5	1900
REM60-4824SW	18-75	24	2500	90	730
REM60-4812DW	18-75	±12	±2500	90	±1500
REM60-4815DW	18-75	±15	±2000	90	±940

**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



UL62368-1 certified  
 CAN/CSA-C22.2 No. 62368-1-14 certified  
 IEC/EN62368-1 certified  
 IEC/EN60601-1 3rd Edition certified  
 ANSI/AAMI ES60601-1 certified  
 CAN/CSA-C22.2 No. 60601-1:14 certified  
 EN60601-1-2 compliant  
 EN55033/35 compliant

### 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	nom. $V_{IN}$ = 24VDC		9VDC	24VDC	36VDC
	nom. $V_{IN}$ = 48VDC		18VDC	48VDC	75VDC
Input Surge Voltage	3 second max.	nom. $V_{IN}$ = 24VDC			50VDC
		nom. $V_{IN}$ = 48VDC			100VDC
Under Voltage Lockout (UVLO)	nom. $V_{IN}$ = 24VDC	DC-DC ON			9VDC
		DC-DC OFF	7.8VDC	8VDC	8.6VDC
	nom. $V_{IN}$ = 48VDC	DC-DC ON			18VDC
		DC-DC OFF	15.8VDC	16VDC	17.4VDC
Quiescent Current	nom. $V_{IN}$ = 24VDC				15mA
	nom. $V_{IN}$ = 48VDC				10mA
Output Voltage Trimming	REM60-xx05; REM60-xx5.1; REM60-xx12		-10%		+10%
	REM60-xx15; REM60-xx24		-10%		+20%
Minimum Load			0%		
Start-up Time	ON/OFF CTRL			30ms	60ms
	Power up			30ms	60ms
Rise Time				10ms	
ON/OFF CTRL <sup>(3)</sup>	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				3mA	
Internal Operating Frequency	100% load at nominal $V_{IN}$		225kHz	250kHz	275kHz
Output Ripple and Noise (20MHz BW)	with a 10µF X7R MLCC	REM60-xx05; REM60-xx5.1		75mVp-p	
		REM60-xx12; REM60-xx15		100mVp-p	
	with a 4.7µF X7R MLCC	REM60-xx24		150mVp-p	
Remote Sense <sup>(4)</sup>	% of nom. $V_{OUT}$				10%

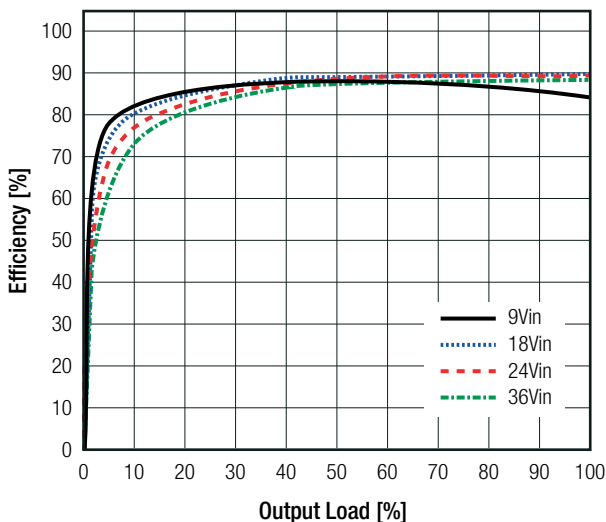
**Notes:**

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

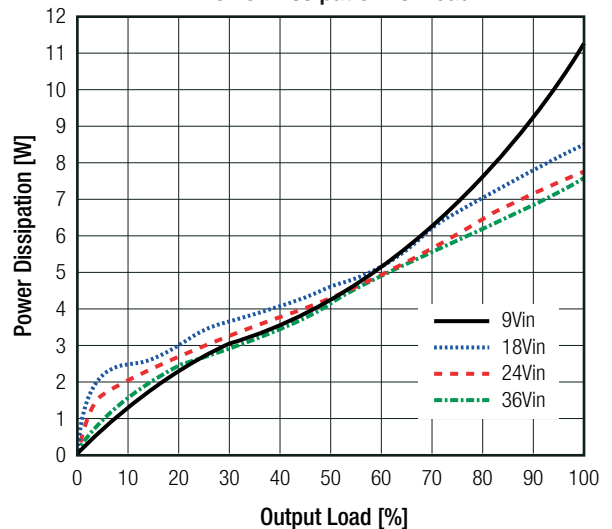
Note4: If remote sense is not being used, Sense pins should be connected to corresponding polarity output pins.

**REM60-2405SW**

**Efficiency vs. Load**



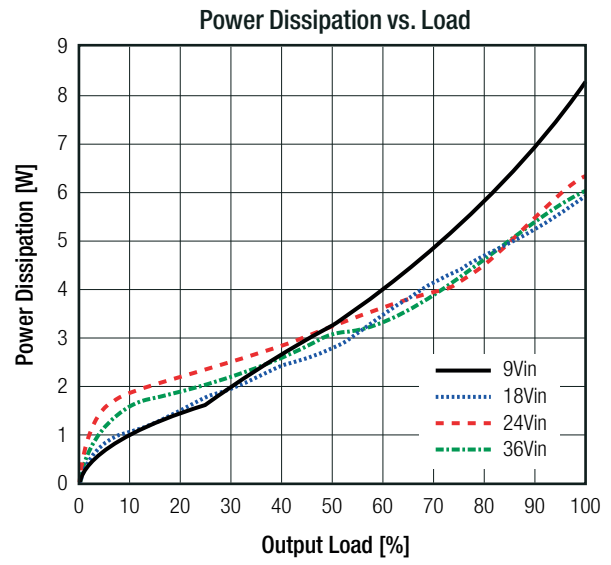
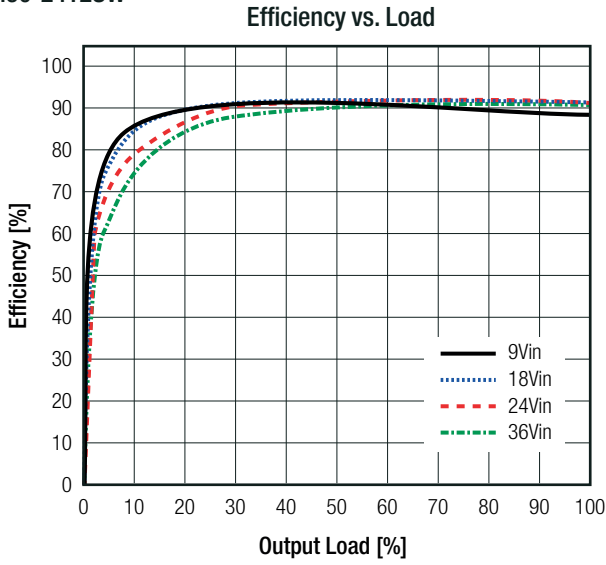
**Power Dissipation vs. Load**



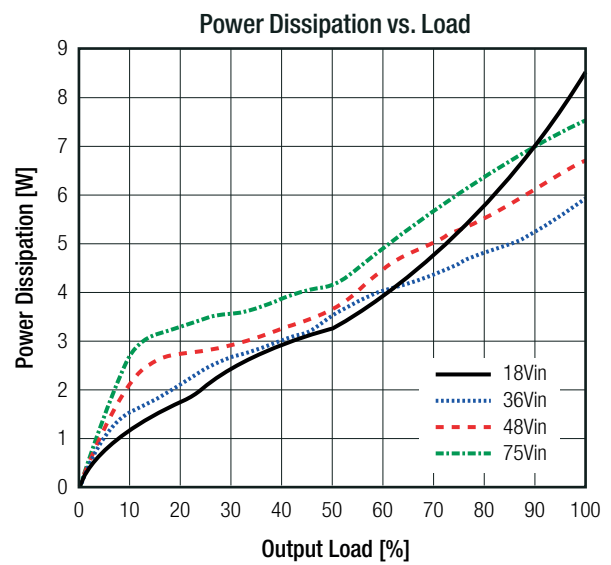
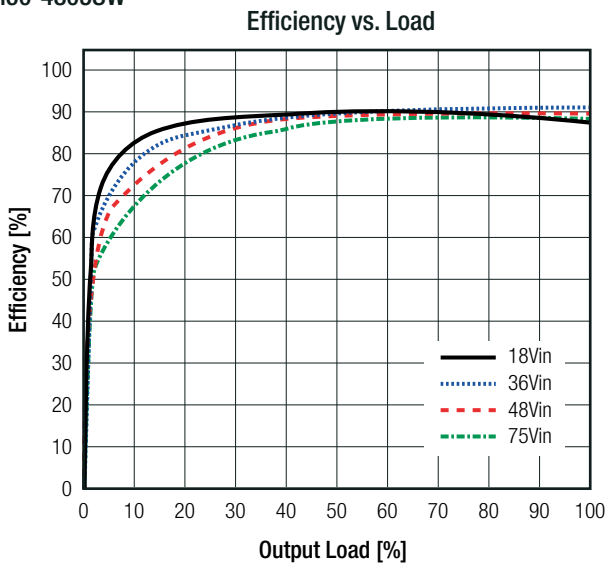
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Specifications (measured @ Ta= 25°C, nom. Vin, full load and after warm-up unless otherwise stated)

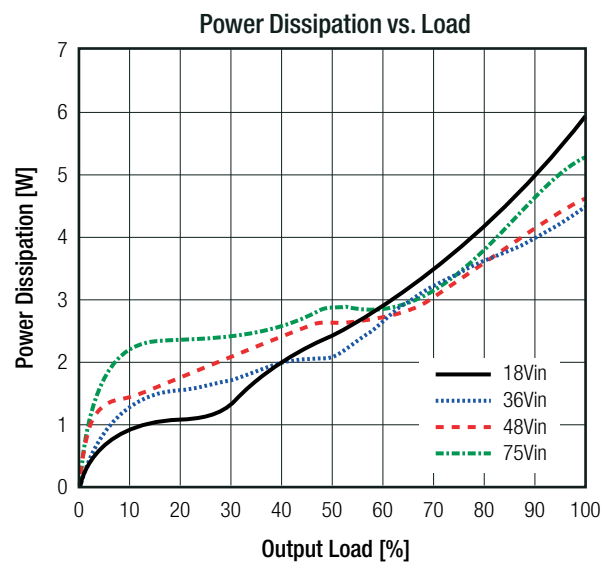
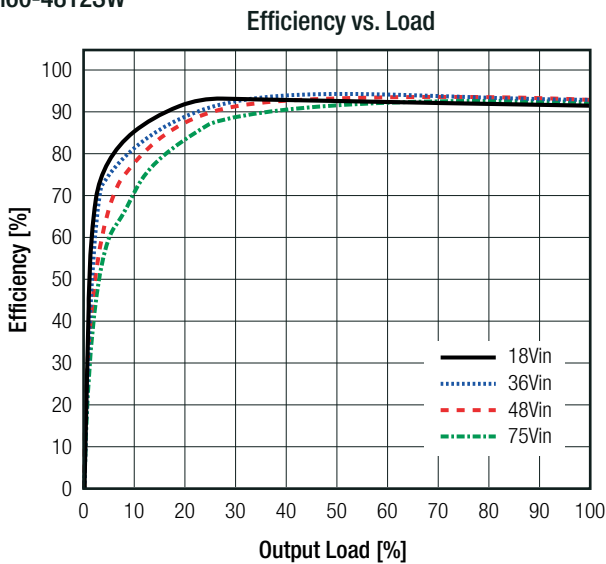
REM60-2412SW



REM60-4805SW



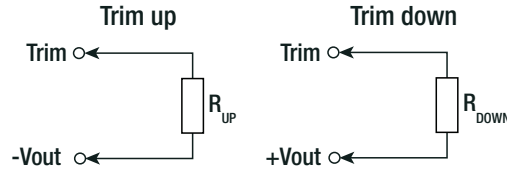
REM60-4812SW



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

**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 external Trim resistor needs to be at least 1/16W rated. The values for trim resistors shown in trim tables below are according to standard E96 values; therefore, the specified voltage may slightly vary.



**REM60-xx05W**

$\Delta V_{out} =$	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	[ $\Omega$ ]
$\Delta V_{out} =$	-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	[ $\Omega$ ]

**REM60-xx5.1W**

$\Delta V_{out} =$	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	[ $\Omega$ ]
$\Delta V_{out} =$	-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	[ $\Omega$ ]

**REM60-xx12W**

$\Delta V_{out} =$	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]
$R_{UP} (E96) =$	393k	174k	102k	66k5	45k3	32k4	22k1	15k	9k31	4k64	[ $\Omega$ ]
$\Delta V_{out} =$	-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	10.80	[VDC]
$R_{DOWN} (E96) =$	432k	200k	121k	78k7	54k9	38k3	26k7	17k4	10k7	5k11	[ $\Omega$ ]

**REM60-xx15W**

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_{set}} =$	15.15	15.30	15.45	15.60	15.75	15.90	16.05	16.20	16.35	16.50	[VDC]
$R_{UP} (E96) =$	412k	200k	127k	88k7	68k1	53k6	42k2	34k8	28k7	23k7	[ $\Omega$ ]
$\Delta V_{out} =$	11	12	13	14	15	16	17	18	19	20	[%]
$V_{out_{set}} =$	16.65	16.80	16.95	17.10	17.25	17.40	17.55	17.70	17.85	18.00	[VDC]
$R_{UP} (E96) =$	20k	16k5	13k7	11k3	9k31	7k5	5k76	4k42	3k09	1k96	[ $\Omega$ ]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_{set}} =$	14.85	14.70	14.55	14.40	14.25	14.10	13.95	13.80	13.65	13.50	[VDC]
$R_{DOWN} (E96) =$	301k	133k	78k7	51k1	35k7	24k9	17k4	11k8	7k5	3k92	[ $\Omega$ ]

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

**REM60-xx24W**

$\Delta V_{out} =$	1	2	3	4	5	6	7	8	9	10	[%]
$V_{out_{set}} =$	24.24	24.48	24.72	24.96	25.20	25.44	25.68	25.92	26.16	26.40	[VDC]
$R_{UP} (E96) =$	953k	475k	301k	215k	165k	127k	102k	82k5	68k1	56k2	[ $\Omega$ ]
$\Delta V_{out} =$	11	12	13	14	15	16	17	18	19	20	[%]
$V_{out_{set}} =$	26.64	26.88	27.12	27.36	27.60	27.84	28.08	28.32	28.56	28.80	[VDC]
$R_{UP} (E96) =$	46k4	38k3	30k9	24k9	20k	15k4	11k3	7k68	4k53	1k62	[ $\Omega$ ]
$\Delta V_{out} =$	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	[%]
$V_{out_{set}} =$	23.76	23.52	23.28	23.04	22.80	22.56	22.32	22.08	21.84	21.60	[VDC]
$R_{DOWN} (E96) =$	732k	324k	191k	127k	86k6	59k	40k2	26k1	15k4	6k49	[ $\Omega$ ]

**REGULATIONS**

Parameter	Condition		Value
Output Accuracy			$\pm 1\%$ max.
Line Regulation	low line to high line, full load		$\pm 0.2\%$ max.
Load Regulation	0% to 100%	single output	0.2% max.
		dual output	1.0% max.
Cross Regulation	asymmetrical load 25% / 100% full load	dual output only	$\pm 5.0\%$ max.
Transient Response	25% load step change		$\pm 500\text{mV}$ typ.
Recovery Time			250 $\mu\text{s}$ max.

**PROTECTIONS**

Parameter	Type		Value
Short Circuit Protection (SCP) <sup>(6)</sup>			continuous, auto-recovery
Over Voltage Protection (OVP)	nom. $V_{OUT} = 5\text{VDC}, 5.1\text{VDC}, 12\text{VDC}$		120% typ., hiccup mode
	nom. $V_{OUT} = 15\text{VDC}, 24\text{VDC}$		130% typ., hiccup mode
	nom. $V_{OUT} = \pm 12\text{VDC}, \pm 15\text{VDC}$		120% typ., hiccup mode
Over Load Protection (OLP)	% of $I_{OUT}$ rated		150% - 195%, hiccup mode
Over Temperature Protection (OTP)	measured on „tc-point“		110 $^\circ\text{C} \pm 5^\circ\text{C}$
Isolation Voltage <sup>(6)</sup>	I/P to O/P	1 minute	5kVAC
Isolation Resistance			10G $\Omega$ min.
Isolation Capacitance			40pF typ.
Insulation Grade	working voltage 250VAC		reinforced
Means of Protection			2MOPP
Leakage Current	240VAC, 60Hz		4 $\mu\text{A}$ typ. / 4.5 $\mu\text{A}$ max.
Internal Clearance			8mm min.
Internal Creepage			8mm min.

**Notes:**

Note5: Refer to local safety regulations if input over-current protection is also required.

Recommended fuse: REM60-24xx: F10A fast-acting type  
REM60-48xx: T6.3A slow-blow type

Note6: For repeat Hi-Pot testing, reduce the time and/or the test voltage

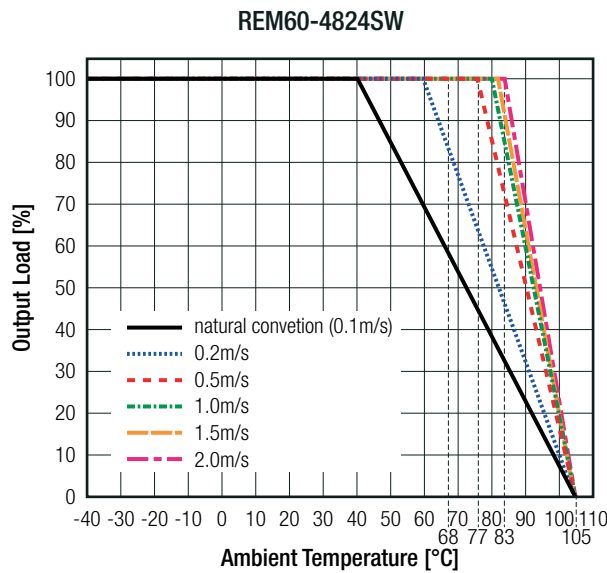
**Specifications** (measured @ Ta= 25°C, nom. Vin, full load and after warm-up unless otherwise stated)

**ENVIRONMENTAL**

Parameter	Condition		Value
Operating Temperature Range	with derating @ natural convection 0.1m/s	refer to „Derating Graph“	-40°C to +105°C
Maximum Case Temperature	refer to „tc-point“		+105°C max.
Temperature Coefficient			0.02%/K
Thermal Impedance	vertical direction	@ natural convection 0.1m/s	9.7K/W
Operating Altitude			5000m
Operating Humidity	non-condensing		5% - 95% RH max.
Pollution Degree			PD2
Thermal Shock			according to MIL-STD-810F
Vibration			according to MIL-STD-810F
MTBF	according to MIL-HDBK-217F, G.B.	full load, T <sub>AMB</sub> = +25°C	1064 x 10 <sup>3</sup> hours

**Derating Graph**

(@ Chamber and nominal Vin)



**SAFETY AND CERTIFICATIONS**

Certificate Type (Safety)	Report Number	Standard
Audio/Video, information and communication technology equipment - Part1: Safety requirements 2nd Edition	E196683	UL62368-1:2014 2nd Edition CAN/CSA-C22.2 No. 62368-1-14 2nd Edition
Audio/Video, information and communication technology equipment - Part1: Safety requirements 2nd Edition	221005201	IEC62368-1:2014 2nd Edition EN62368-1:2014+A11:2017
Medical electrical equipment Part 1: General requirements for basic safety and essential performance	221005101	IEC60601-1:2005+AM1:2012 3rd Edition EN60601-1:2006+A1:2013+A12:2014
Medical electrical equipment Part 1: General requirements for basic safety and essential performance	E314885	ANSI/AAMI ES60601-1:2005(R)2012+A2:2010(R)2012 CAN/CSA-C22.2 No. 60601-1:14 3rd Edition
RoHS2		RoHS 2011/65/EU + AM2015/863

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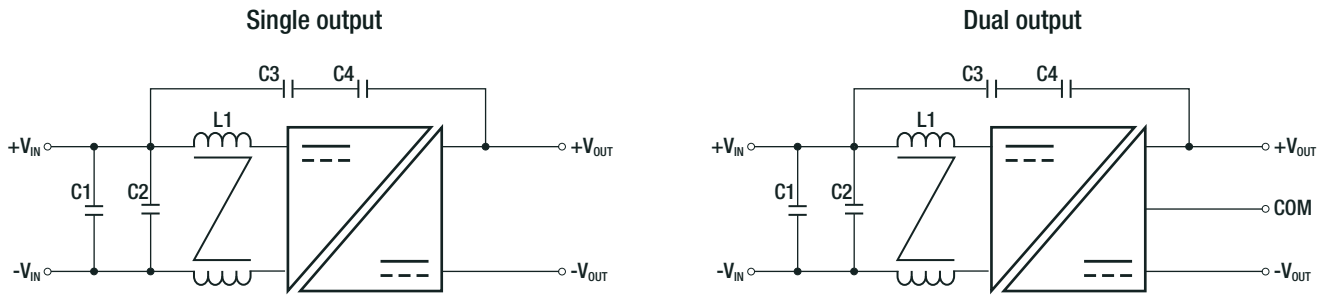
**Specifications** (measured @ Ta= 25°C, nom. Vin, full load and after warm-up unless otherwise stated)

EMC Compliance	Condition	Standard / Criterion
Medical electrical equipment Part 1-2: General requirements for basic safety and essential performance		EN60601-1-2:2015
Electromagnetic compatibility of multimedia equipment – Emission Requirements	with external filter	EN55032:2015+AC:2016, Class A EN55032:2015+AC:2016, Class B
Electromagnetic compatibility of multimedia equipment – Immunity requirements		EN55035:2017+A11:2020
ESD Electrostatic Discharge Immunity Test	Air: ±15kV, Contact ±8kV	EN61000-4-2, Criteria A
Radiated, Radio-Frequency, Electromagnetic Field Immunity Test	10V/m	EN61000-4-3, Criteria A
Fast Transient and Burst Immunity <sup>(7)</sup>	DC Power Port: ±2kV	EN61000-4-4, Criteria A
Surge Immunity <sup>(7)</sup>	DC Power Port: ±2kV	EN61000-4-5, Criteria A
Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields	10Vrms	EN61000-4-6, Criteria A
Power Magnetic Field Immunity	100A/m (continuous) 1000A/m (1s)	EN61000-4-8, Criteria A

**Notes:**

Note7: 24Vin models tested with 2pcs of Nippon chemi-con KY series (220µF/100V) E-cap and a TVS (SMDJ58A. 58V. 3000W peak pulse power) in parallel  
48Vin models tested with 2pcs of Nippon chemi-con KY series (220µF/100V) E-cap and a TVS (SMDJ120A. 120V. 3000W peak pulse power) in parallel

**EMC Filtering Suggestions according to EN55032 Class A**



**Component List Class A**

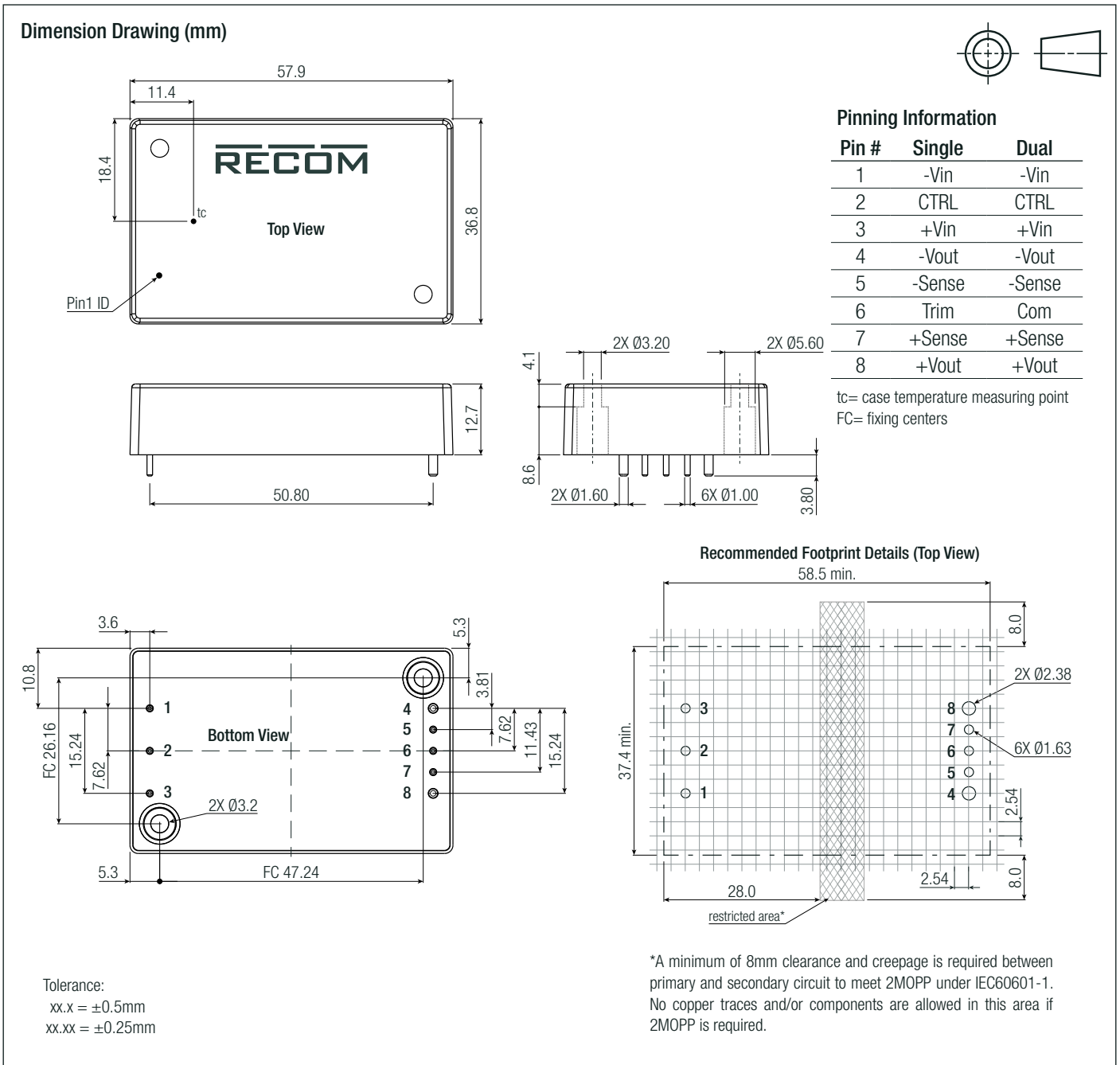
nom. Vin	C1	C2	C3, C4	L1
24, 48VDC	100µF	2.2µF	100pF	285µH

**DIMENSION AND PHYSICAL CHARACTERISTICS**

Parameter	Type	Value
Material	case/baseplate	non-conductive black plastic, (UL94 V-0)
	potting	silicone, (UL94 V-0)
	PCB	FR4, (UL94 V-1)
Dimension (LxWxH)		57.9 x 36.8 x 12.7mm
Weight		51g typ.

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



### PACKAGING INFORMATION

Parameter	Type	Value
Packaging Dimension (LxWxH)	tray	157.0 x 88.0 x 23.0mm
Packaging Quantity		2pcs
Storage Temperature Range		-55°C to +125°C
Storage Humidity	non-condensing	95% RH max.

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