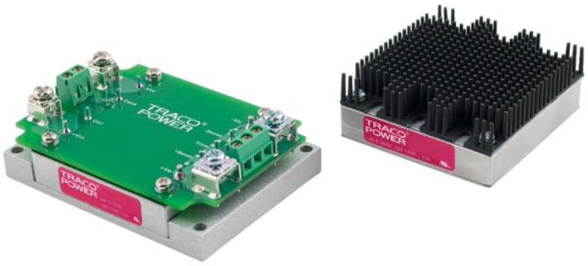
TRACO POWER

TEP 160-WIR Series Application Note

DC/DC Converter 8.5 (9.0) to 36Vdc or 16.5 to 75 Vdc and 43 to 160Vdc Input 3.3 to 48Vdc Single Outputs, up to 182W Output Power



pending

Complete TEP 160-WIR datasheet can be downloaded at:
http://www.tracopower.com/products/tep160wir.pdf

Features

- Industry standard half-brick footprint
- 61.0×57.9×12.7 mm (2.40×2.28×0.50 inch)
- RoHS directive compliant
- Six-sided continuous shield
- for 24VIN, 48VIN and 72VIN module
- Soft-start
- High power density of 66.5W / inch^3
- 4:1 ultra wide input voltage range
- High efficiency up to 91%
- Input to output → basic Insulation: 2'250 VDC
- Output current up to 43A
- Adjustable output voltage
- No minimum load required
- Railway application

Options

- Negative logic remote ON/OFF
- Case pin
- Synchronous
- Terminal block

Applications

- Wireless Network
- Telecom/ Datacom
- Industry Control System
- Distributed Power Architectures
- Semiconductor Equipment
- Railway System

General Description

The TEP 160-WIR series offer up to 182 watts of output power from a 61.0×57.9×12.7mm industry standard half-brick package and footprint with a 4:1 ultra wide input voltage of 8.5 (9)~36Vdc, 16.5~75Vdc and 43~160Vdc and adjustable output voltage. The product features 2'250VDC of isolation for 60 seconds (basic insulation), short circuit and over voltage protection, as well as six sided shielding.

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Output Specification					
Parameter	Device	Min	Typ	Max	Unit
Output Voltage					
($V_{in} = V_{in\,nom}$, Full Load , T_A = 25°C)	TEP 160-xx10WIR	3.267	3.3	3.333	Vdc
	TEP 160-xx11WIR	4.95	5	5.05	Vdc
	TEP 160-xx12WIR	11.88	12	12.12	Vdc
	TEP 160-xx13WIR	14.85	15	15.15	Vdc
	TEP 160-xx15WIR	23.76	24	24.24	Vdc
	TEP 160-xx16WIR	27.72	28	28.28	Vdc
	TEP 160-xx18WIR	47.52	48	48.48	Vdc
Voltage Adjustability (see page 56 & 57)	All	-20		+10	%
Output Regulation					
Line ($V_{in\,min}$ to $V_{in\,max}$ at Full Load)	All		±0.1	±0.2	%
Load (0% to 100% of Full Load)	All		±0.1	±0.2	%
Output Ripple & Noise					
($V_{in} = V_{in\,nom}$, Full Load , T_A = 25°C)					
Peak to Peak (5Hz to 20MHz bandwidth)					
Measured with a ripple &noise test board:					
$C_{OUT,\,ext.}$ = 1µF 25V 1206 X7R MLCC and	TEP 160-xx10WIR		75	100	mV pk-pk
22µF 25V D-type POS-CAP	TEP 160-xx11WIR		75	100	mV pk-pk
	TEP 160-xx12WIR		100	125	mV pk-pk
	TEP 160-xx13WIR		100	125	mV pk-pk
$C_{OUT,\,ext.}$ = 4.7µF 50V 1812 X7R MLCC	TEP 160-xx15WIR		200	250	mV pk-pk
	TEP 160-xx16WIR		200	250	mV pk-pk
$C_{OUT,\,ext.}$ = 2.2µF 100V 1812 X7R MLCC	TEP 160-xx18WIR		300	350	mV pk-pk
Temperature Coefficient	All	-0.02		+0.02	%/°C
Output Voltage Overshoot ($V_{in} = V_{in\,min}$ to $V_{in\,max}$, Full Load , T_A = 25°C).	All		0	5	% Vout
Dynamic Load Response					
($V_{in} = V_{in\,nom}$, T_A = 25°C)					
Load step change between 75% to 100% of Full	TEP 160-xx10WIR		300		mV
Load	TEP 160-xx11WIR		600		mV
Peak Deviation	TEP 160-xx12WIR		900		mV
	TEP 160-xx13WIR		900		mV
	TEP 160-xx15WIR		900		mV
	TEP 160-xx16WIR		1100		mV
	TEP 160-xx18WIR		1200		mV
Setting Time (Vout < 10% peak deviation)	All		250		µS

Output Specification (continued)					
Parameter	Device	Min	Typ	Max	Unit
Output Current	TEP 160-2410WIR	0		40.0	A
	TEP 160-2411WIR	0		28.0	A
	TEP 160-2412WIR	0		12.0	A
	TEP 160-2413WIR	0		9.5	A
	TEP 160-2415WIR	0		6.0	A
	TEP 160-2416WIR	0		5.0	A
	TEP 160-2418WIR	0		3.0	A
	TEP 160-4810WIR	0		40.0	A
	TEP 160-4811WIR	0		30.0	A
	TEP 160-4812WIR	0		13.0	A
	TEP 160-4813WIR	0		10.0	A
	TEP 160-4815WIR	0		6.5	A
	TEP 160-4816WIR	0		5.5	A
	TEP 160-4818WIR	0		3.2	A
	TEP 160-7210WIR	0		43.0	A
	TEP 160-7211WIR	0		32.0	A
	TEP 160-7212WIR	0		15.0	A
	TEP 160-7213WIR	0		12.0	A
	TEP 160-7215WIR	0		7.5	A
	TEP 160-7216WIR	0		6.5	A
	TEP 160-7218WIR	0		3.8	A
Output Capacitor Load	TEP 160-2410WIR			121'000	µF
	TEP 160-2411WIR			56'000	µF
	TEP 160-2412WIR			10'000	µF
	TEP 160-2413WIR			6'300	µF
	TEP 160-2415WIR			2'500	µF
	TEP 160-2416WIR			1'700	µF
	TEP 160-2418WIR			620	µF
	TEP 160-4810WIR			121'000	µF
	TEP 160-4811WIR			60'000	µF
	TEP 160-4812WIR			10'800	µF
	TEP 160-4813WIR			6'600	µF
	TEP 160-4815WIR			2'700	µF
	TEP 160-4816WIR			1'900	µF
	TEP 160-4818WIR			660	µF
	TEP 160-7210WIR			130'000	µF
	TEP 160-7211WIR			64'000	µF
	TEP 160-7212WIR			12'500	µF
	TEP 160-7213WIR			8'000	µF
	TEP 160-7215WIR			3'100	µF
	TEP 160-7216WIR			2'300	µF
	TEP 160-7218WIR			790	µF
Output Over Voltage Protection (Hiccup Mode)	TEP 160-xx10WIR	3.795		4.29	Vdc
	TEP 160-xx11WIR	5.75		6.50	Vdc
	TEP 160-xx12WIR	13.80		15.60	Vdc
	TEP 160-xx13WIR	17.25		19.50	Vdc
	TEP 160-xx15WIR	27.60		31.20	Vdc
	TEP 160-xx16WIR	32.20		36.40	Vdc
	TEP 160-xx18WIR	55.20		62.40	Vdc
Output Over Current Protection (Hiccup Mode)	All	120		150	% FL
Output Short Circuit Protection (Hiccup Mode)	All	Automatics recovery			

Input Specification					
Parameter	Device	Min	Typ	Max	Unit
Operating Input Voltage	TEP 160-2410WIR	9	24	36	Vdc
	TEP 160-2411WIR	9	24	36	Vdc
	TEP 160-24xxWIR	8.5	24	36	Vdc
	TEP 160-48xxWIR	16.5	48	75	Vdc
	TEP 160-72xxWIR	43	110	160	Vdc
Input Voltage Continuous	TEP 160-24xxWIR			40	Vdc
	TEP 160-48xxWIR			80	Vdc
	TEP 160-72xxWIR			165	Vdc
Input Voltage Transient (1sec maximum)	TEP 160-24xxWIR			50	Vdc
	TEP 160-48xxWIR			100	Vdc
	TEP 160-72xxWIR			185	Vdc
Input Standby Current	TEP 160-2410WIR		20		mA
($V_{in} = V_{in\,nom}$, No Load, T_A = 25℃)	TEP 160-2411WIR		25		mA
	TEP 160-2412WIR		25		mA
	TEP 160-2413WIR		25		mA
	TEP 160-2415WIR		25		mA
	TEP 160-2416WIR		25		mA
	TEP 160-2418WIR		25		mA
	TEP 160-4810WIR		15		mA
	TEP 160-4811WIR		15		mA
	TEP 160-4812WIR		20		mA
	TEP 160-4813WIR		20		mA
	TEP 160-4815WIR		20		mA
	TEP 160-4816WIR		20		mA
	TEP 160-4818WIR		25		mA
	TEP 160-7210WIR		10		mA
	TEP 160-7211WIR		10		mA
	TEP 160-7212WIR		10		mA
	TEP 160-7213WIR		10		mA
	TEP 160-7215WIR		10		mA
	TEP 160-7216WIR		10		mA
	TEP 160-7218WIR		10		mA
Input reflected ripple current (see page 49) (5 to 20MHz, 12µH source impedance)	All		50		$mA_{pk\text{-}pk}$
Start Up Time	All				
($V_{in} = V_{in\,nom}$ and constant resistive load)					
Power up			75	100	mS
Remote ON/OFF			75	100	mS
Remote ON/OFF (see page 61)	All				
(The CTRL pin voltage is referenced to -INPUT)					
Positive logic (Standard) : Device code without Suffix					
DC-DC ON (Short)		3		12	Vdc
DC-DC OFF (Open)		0		1.2	Vdc
Positive logic (Option) : Device code with Suffix “-N”					
DC-DC ON (Open)		0		1.2	Vdc
DC-DC OFF (Short)		3		12	Vdc
Remote Off state Input Current			3		mA
Input Current of Remote Control Pin		-0.5		1	mA
SYNC pin output signal (see page 62) → Optional	All	-0.3		6	V

Input Specification (continued)					
Parameter	Device	Min	Typ	Max	Unit
Under Voltage Lockout Turn-on Threshold	TEP 160-24xxWIR			9	Vdc
	TEP 160-48xxWIR			18	Vdc
	TEP 160-72xxWIR			43	Vdc
Under Voltage Lockout Turn-off Threshold	TEP 160-24xxWIR	7.3		8.1	Vdc
	TEP 160-48xxWIR	15.5		16.3	Vdc
	TEP 160-72xxWIR	33.0		36.0	Vdc

General Specification					
Parameter	Device	Min	Typ	Max	Unit
Efficiency (Vin = Vin(nom) , Full Load , T_A = 25℃)	TEP 160-2410WIR		88		%
	TEP 160-2411WIR		90		%
	TEP 160-2412WIR		90		%
	TEP 160-2413WIR		91		%
	TEP 160-2415WIR		90		%
	TEP 160-2416WIR		90		%
	TEP 160-2418WIR		90		%
	TEP 160-4810WIR		89		%
	TEP 160-4811WIR		91		%
	TEP 160-4812WIR		91		%
	TEP 160-4813WIR		91		%
	TEP 160-4815WIR		91		%
	TEP 160-4816WIR		91		%
	TEP 160-4818WIR		91		%
	TEP 160-7210WIR		88		%
	TEP 160-7211WIR		90		%
	TEP 160-7212WIR		90		%
	TEP 160-7213WIR		90		%
	TEP 160-7215WIR		90		%
	TEP 160-7216WIR		90		%
	TEP 160-7218WIR		90		%
Isolation voltage for 1 minute (Basic Insulation) Input to Output Input (Output) to Case	All	2250 1600			Vdc Vdc
Isolation resistance	All	1			GΩ
Isolation capacitance	All			2500	PF
Switching Frequency	All	225	250	275	KHz
Weight	All		105		G
MTBF Bellcore TR-NWT-000332, T_C = 40°C, MIL-HDBK-217F	All		1.010×10^6 7.416×10^4		hours hours
Over Temperature Protection (see page 59)	All		120		°C
Case material	TEP 160-24xxWIR TEP 160-48xxWIR TEP 160-72xxWIR	Metal Metal Aluminum base-plate with plastic case			
Base material	TEP 160-24xxWIR TEP 160-48xxWIR TEP 160-72xxWIR	FR4 PCB FR4 PCB FR4 PCB			
Potting material	All	Silicon (UL94-V0)			
Dimensions	All	2.40 x 2.28 x 0.50 (61.0 x 57.9 x 12.7)			Inch (mm)

Environmental Specification					
Parameter	Model	Min	Typ	Max	Unit
Operating case temperature	All	-40		115	°C
Storage temperature	All	-55		125	°C
Over temperature protection (see page 59)	All		120		°C
Thermal impedance* without Heat-sink with Heat-sink with Terminal block Only mount on the iron base-plate	All		6.1 4.6 4.4 2.8		°C/ Watt °C/ Watt °C/ Watt °C/ Watt
Relative humidity	All	5		95	% RH
Thermal shock	EN 61373,MIL-STD-810F				
Vibration	EN 61373,MIL-STD-810F				

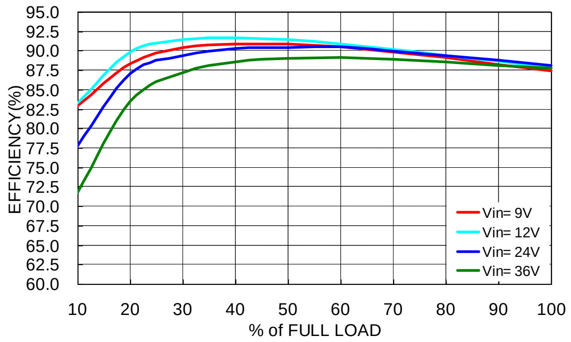
* Test condition with vertical direction by natural convection 20FLM

EMC characteristic**			
EMI (see page 52 - 56)	EN 55011, EN 55022		Class A
ESD	EN 61000-4-2	Air: ±8KV Contact: ±6KV	Performance Criteria A
Radiated immunity	EN 61000-4-3	20V/m	Performance Criteria A
Fast transient	EN 61000-4-4	±2KV	Performance Criteria A
Surge	EN 61000-4-5	±2KV	Performance Criteria A
Conducted immunity	EN 61000-4-6	10Vr.m.s	Performance Criteria A

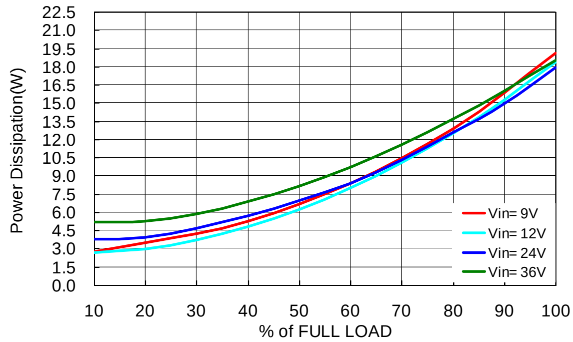
** The TEP 160WIR series meets EMC characteristics only with external components connected before the input pin to the converter. If customer need to comply with EN 61000-4-4, EN 61000-4-5 only, an external input filter capacitor is required. For the TEP 160-24xxWIR and TEP 160-48-xxWIR we recommend to use 2 pcs of aluminum electrolytic capacitors (Nippon Chemi-Con KY series, 220µF/100V, ESR 48mΩ) connected in parallel. For the TEP 160-72-xxWIR we recommend to use 3 pcs of aluminum electrolytic capacitors (Ruby-con BXF series, 100µF/250V) connected in parallel.

Characteristic Curves

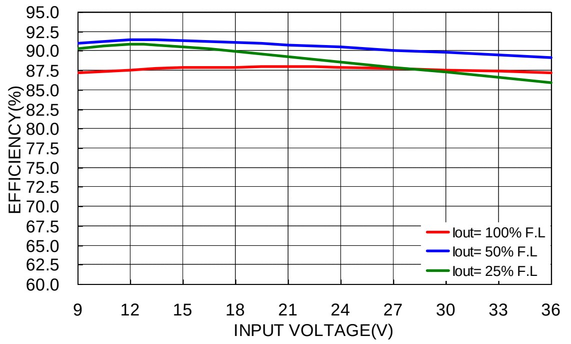
All test conditions are at 25°C. The figures are identical for TEP 160-2410WIR (order on demand)



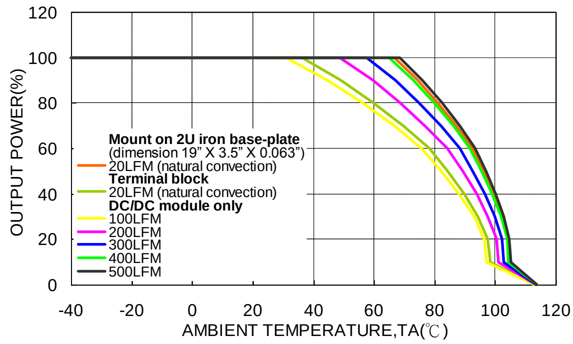
Efficiency versus Output Current



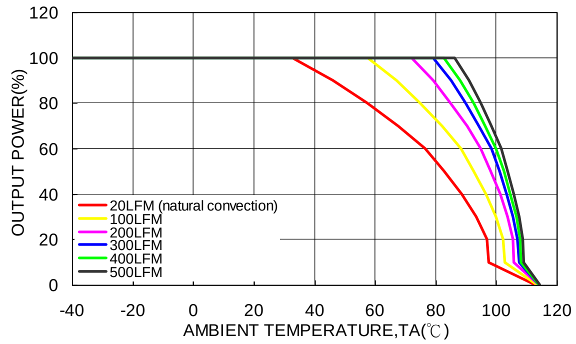
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



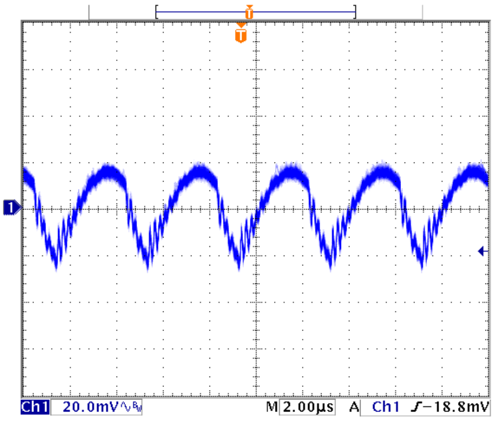
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



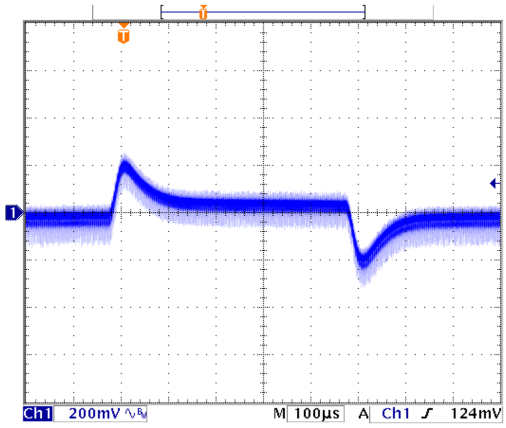
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

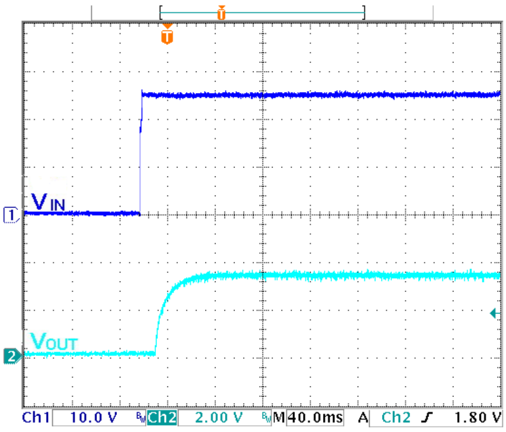
All test conditions are at 25°C. The figures are identical for TEP 160-2410WIR (continued)



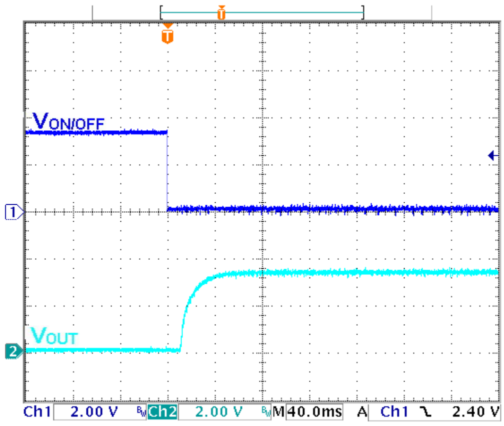
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



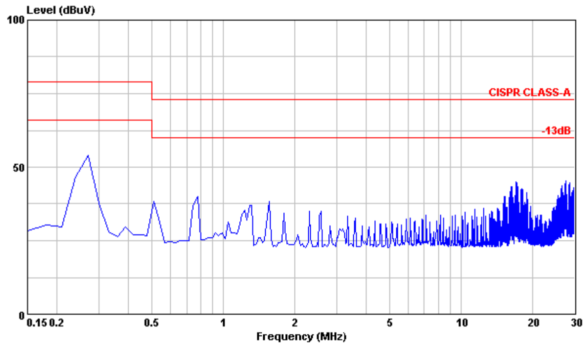
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



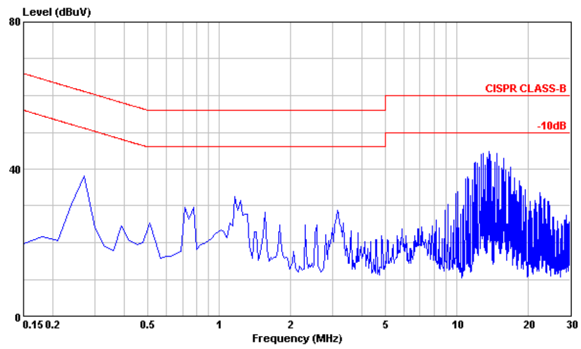
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



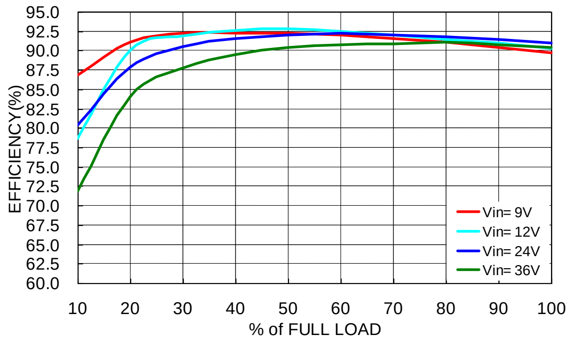
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



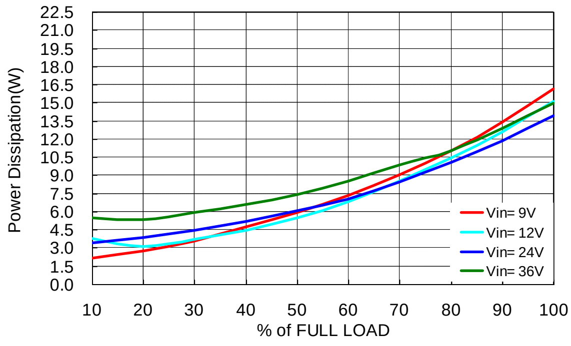
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

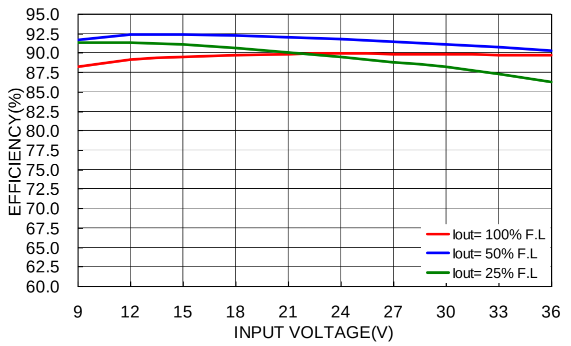
All test conditions are at 25°C. The figures are identical for TEP 160-2411WIR (order on demand)



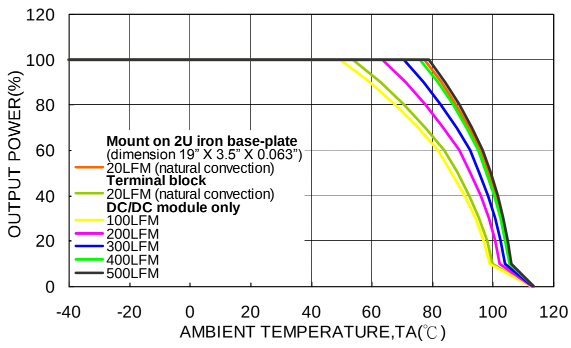
Efficiency versus Output Current



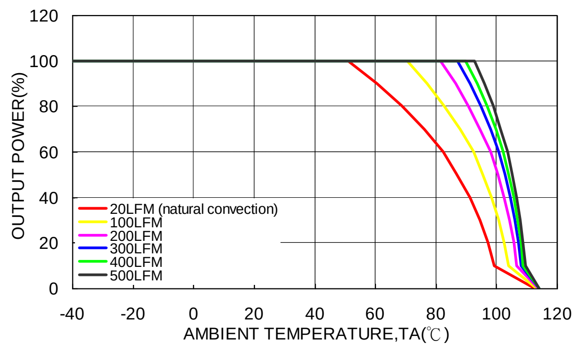
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



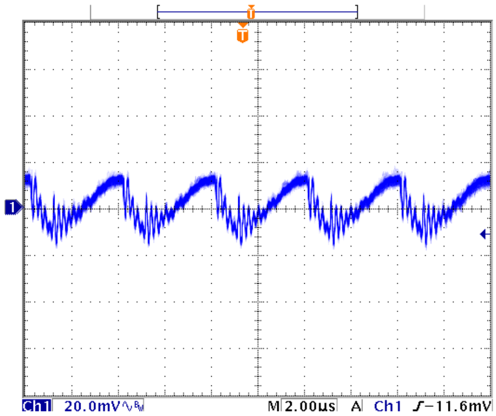
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



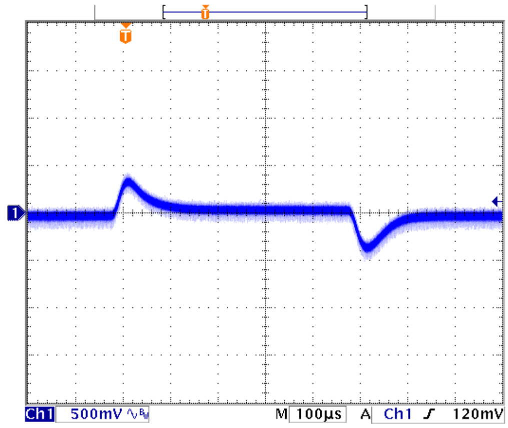
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

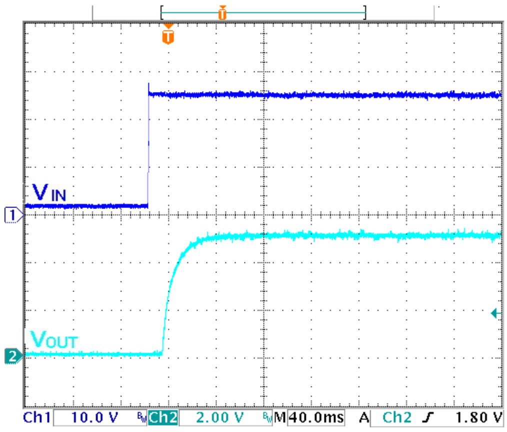
All test conditions are at 25°C. The figures are identical for TEP 160-2411WIR (continued)



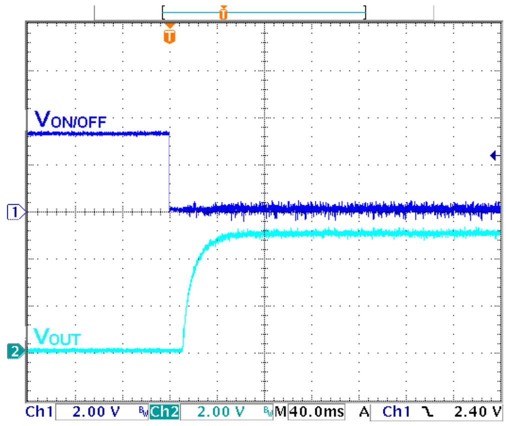
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



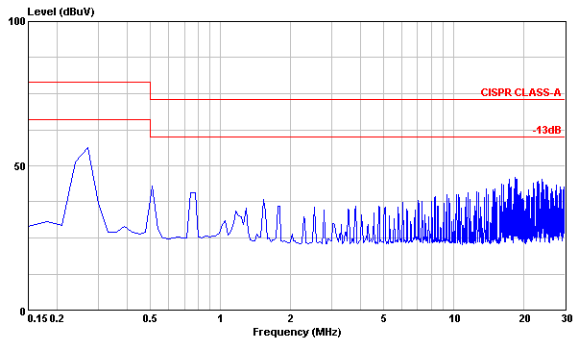
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



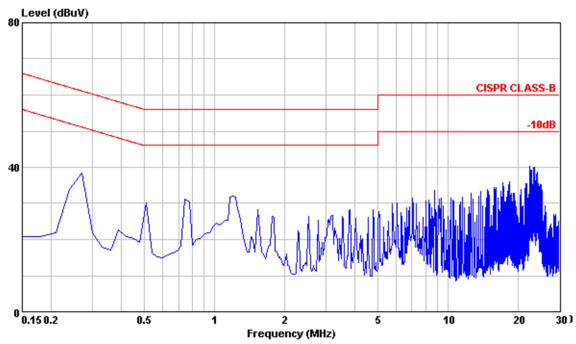
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



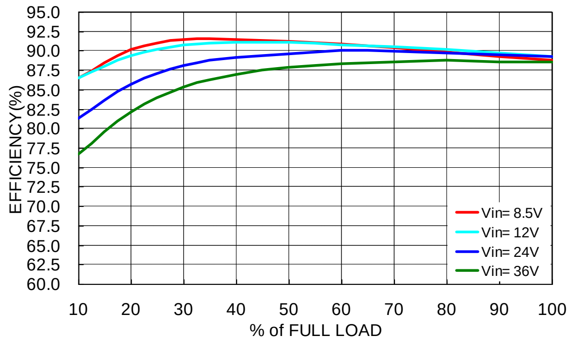
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



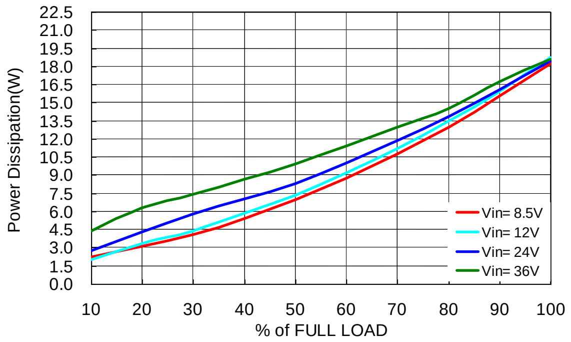
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

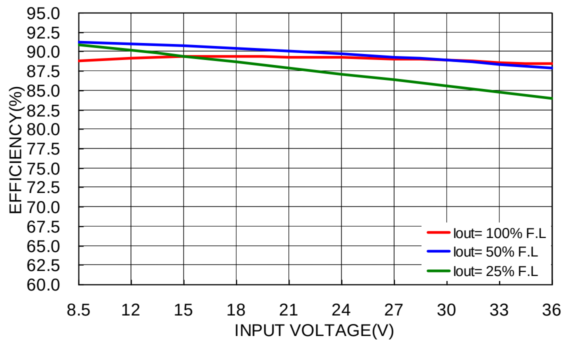
All test conditions are at 25°C. The figures are identical for TEP 160-2412WIR



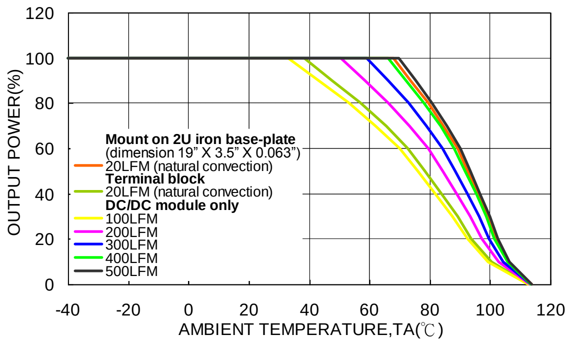
Efficiency versus Output Current



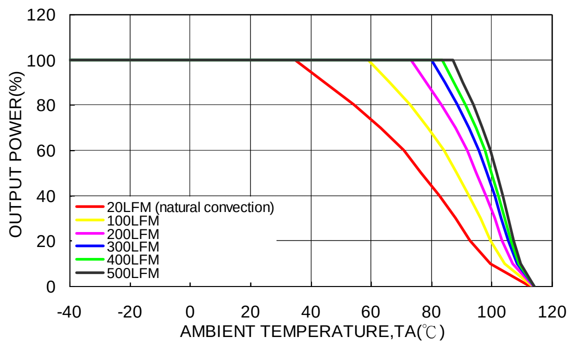
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



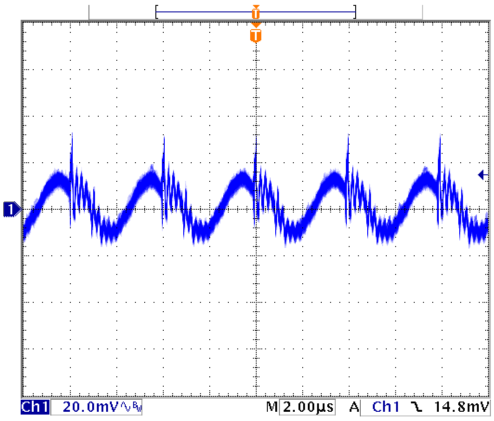
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



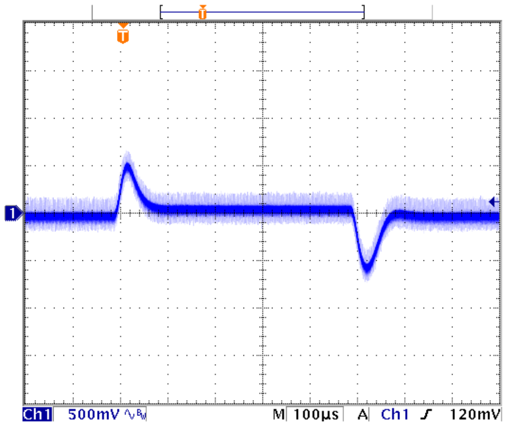
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

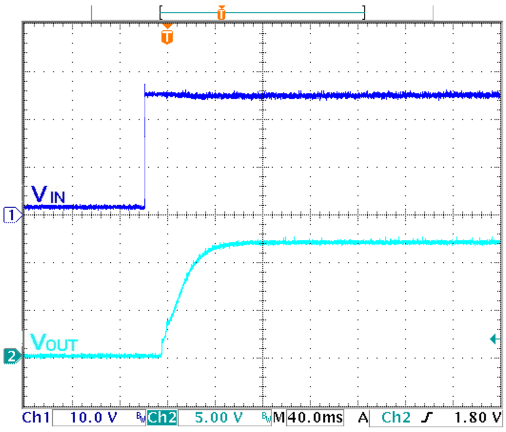
All test conditions are at 25°C. The figures are identical for TEP 160-2412WIR (continued)



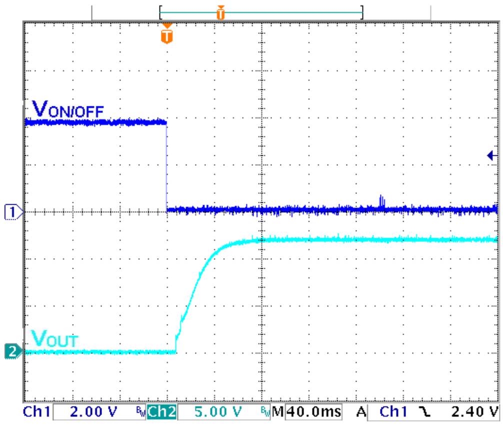
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



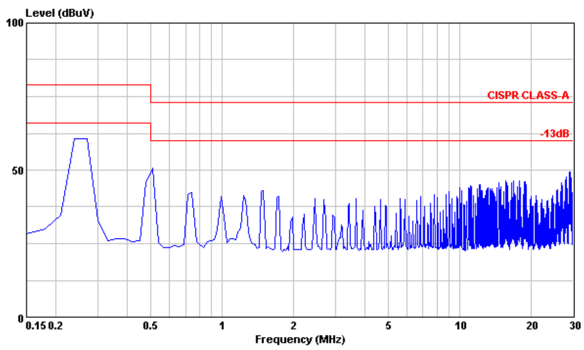
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



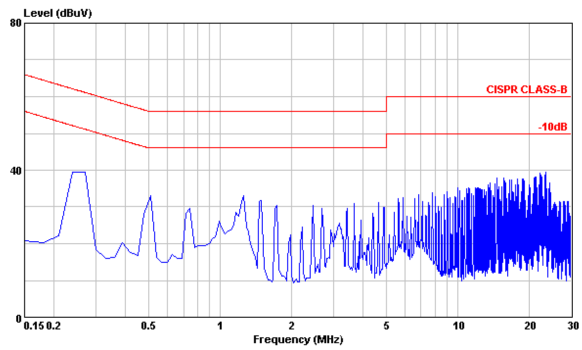
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



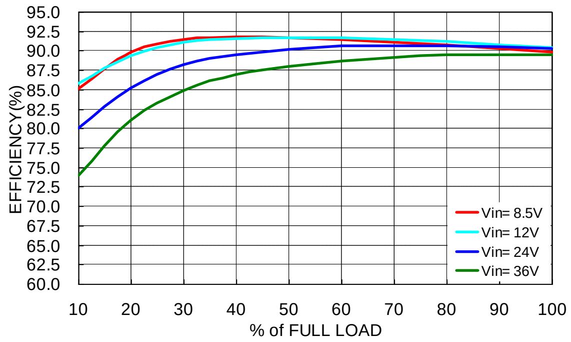
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



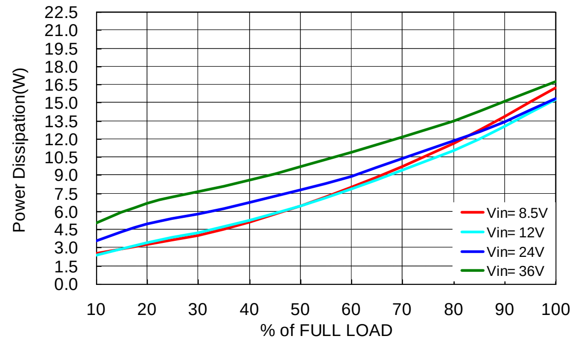
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

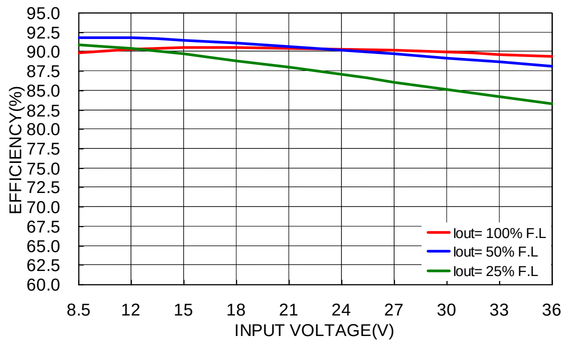
All test conditions are at 25°C. The figures are identical for TEP 160-2413WIR



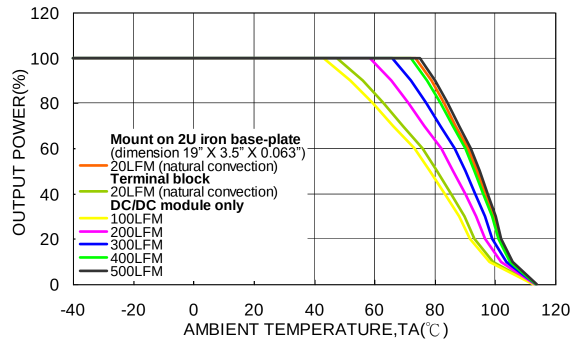
Efficiency versus Output Current



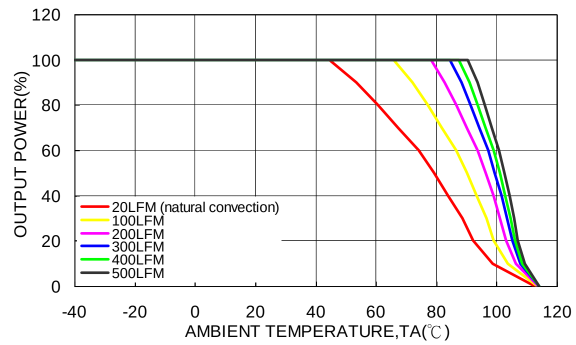
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



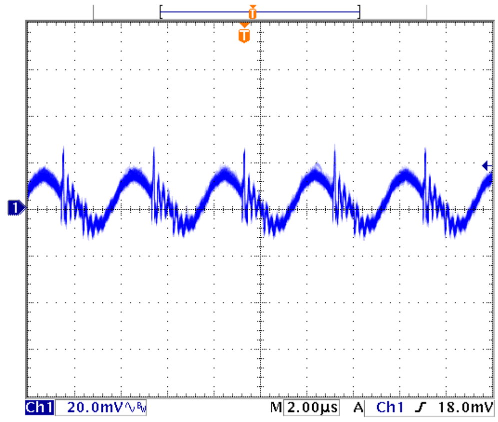
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



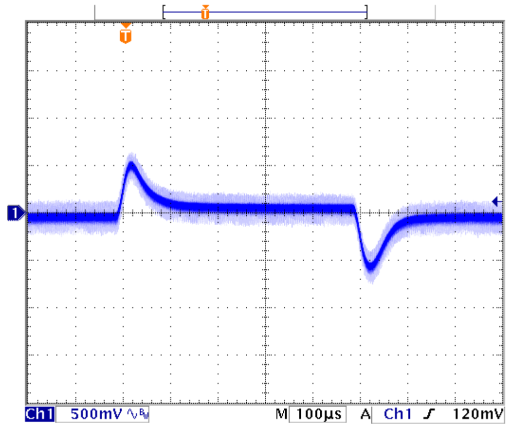
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

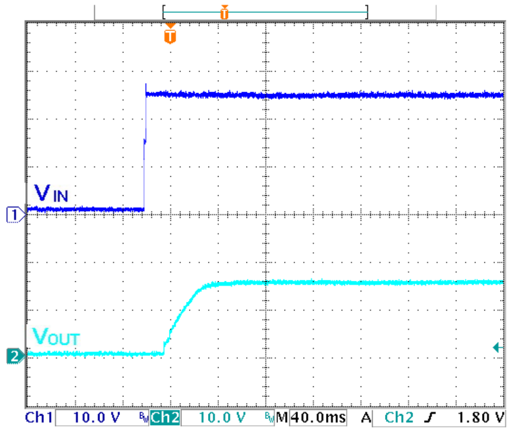
All test conditions are at 25°C. The figures are identical for TEP 160-2413WIR (continued)



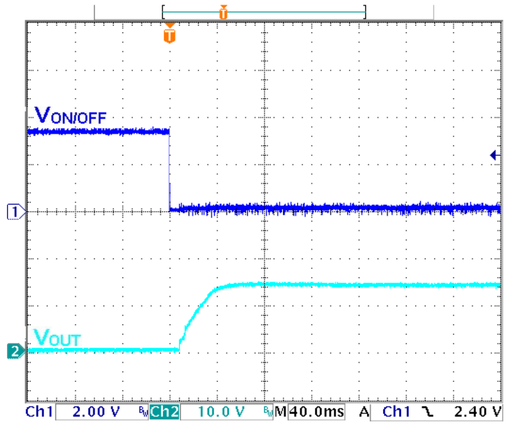
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



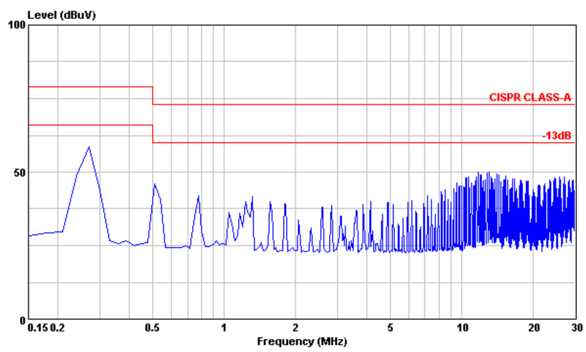
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



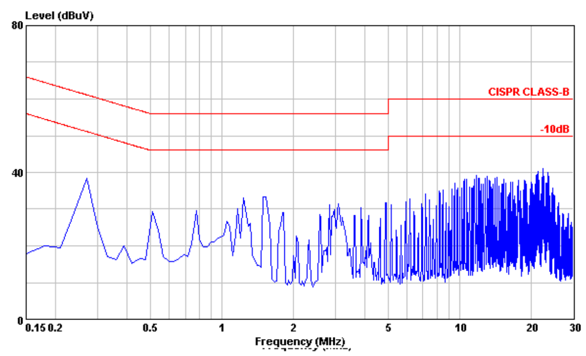
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



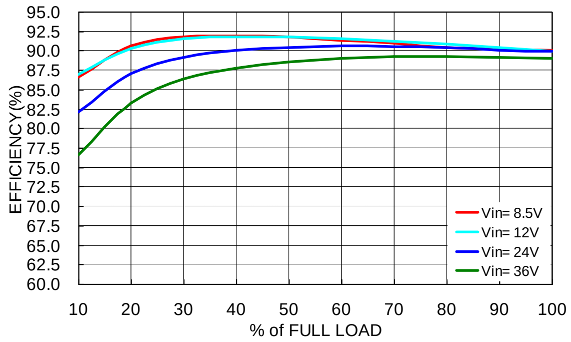
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



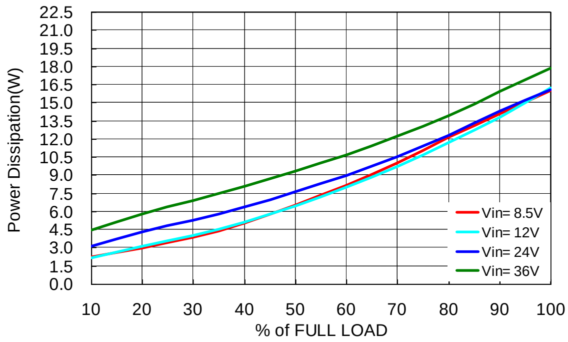
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

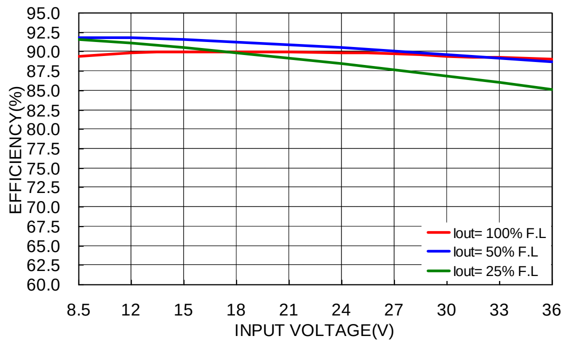
All test conditions are at 25°C. The figures are identical for TEP 160-2415WIR



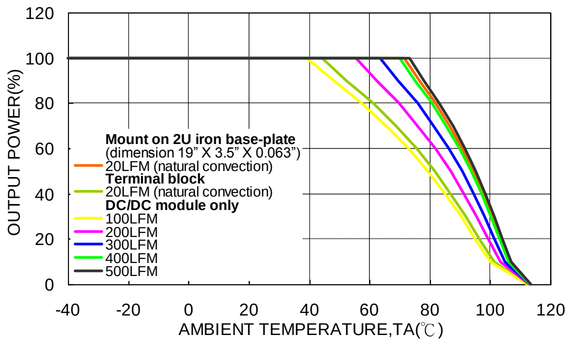
Efficiency versus Output Current



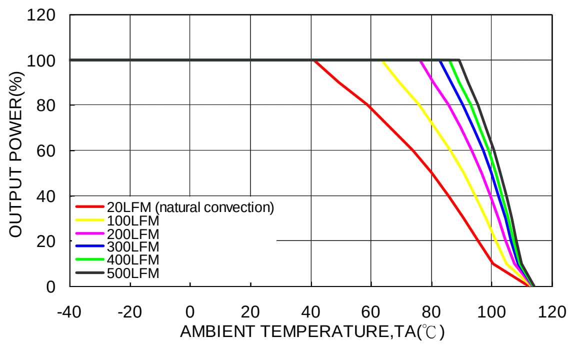
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



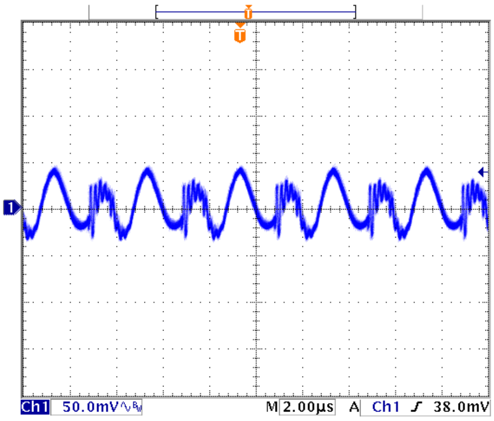
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



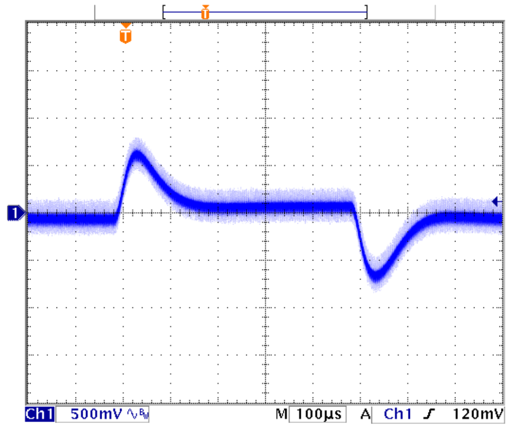
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

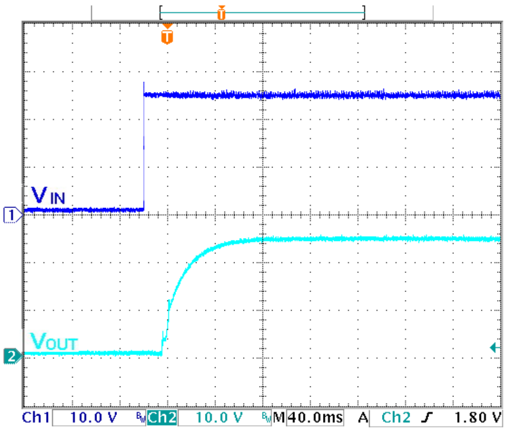
All test conditions are at 25°C. The figures are identical for TEP 160-2415WIR (continued)



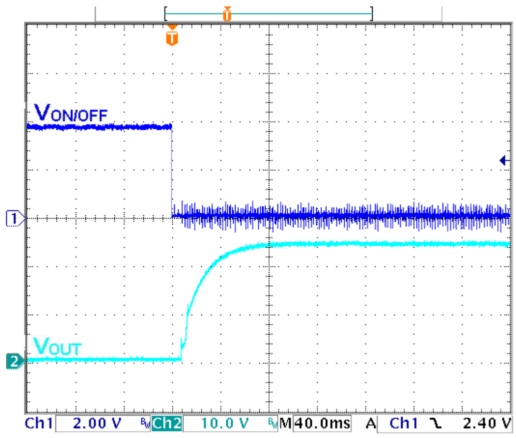
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



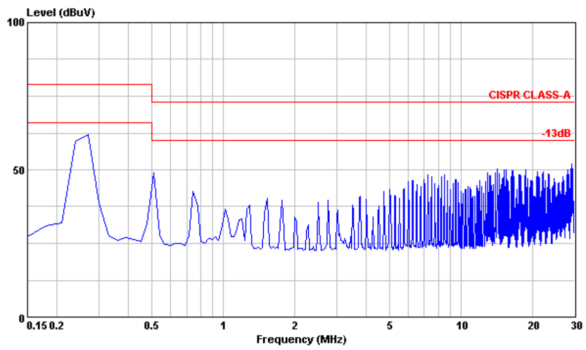
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



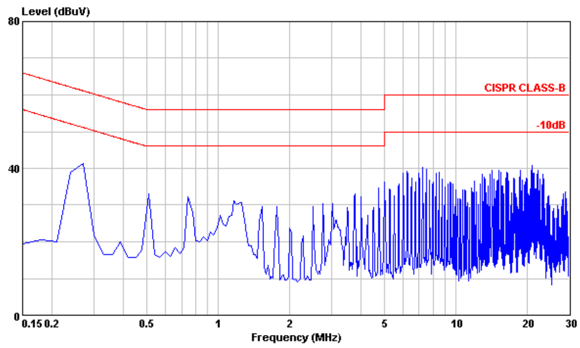
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



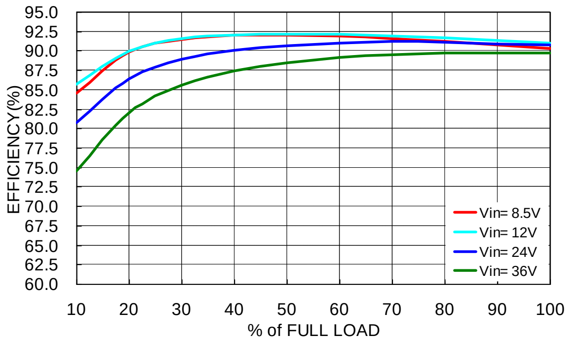
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



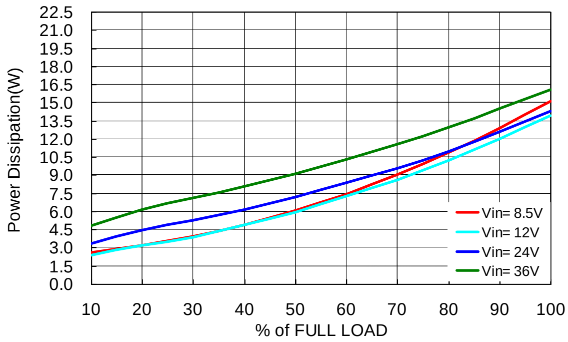
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

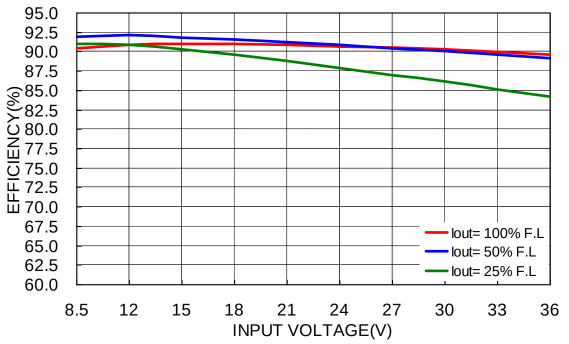
All test conditions are at 25°C. The figures are identical for TEP 160-2416WIR



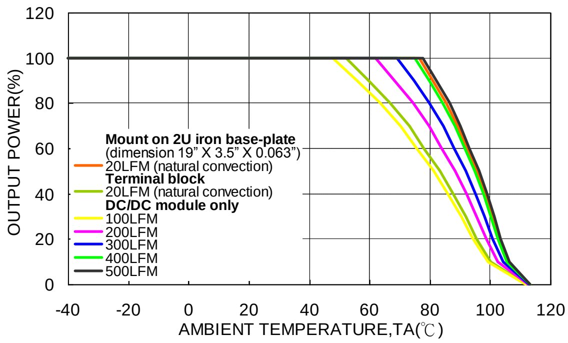
Efficiency versus Output Current



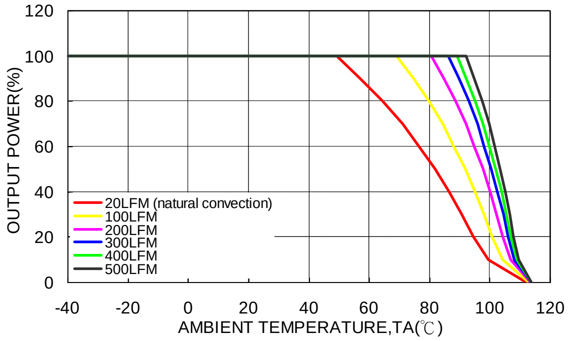
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



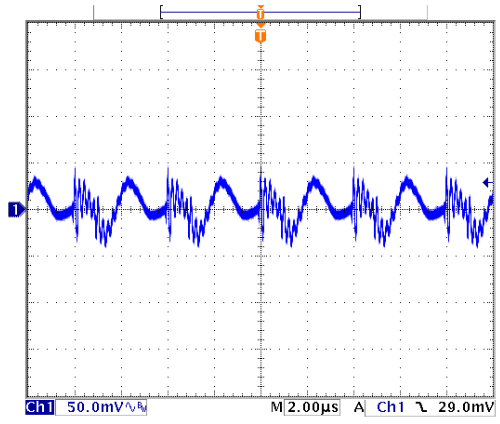
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



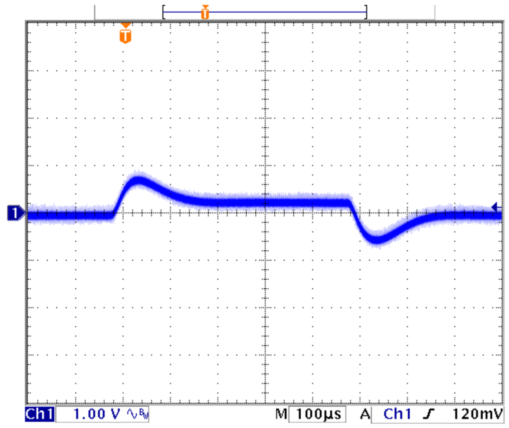
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

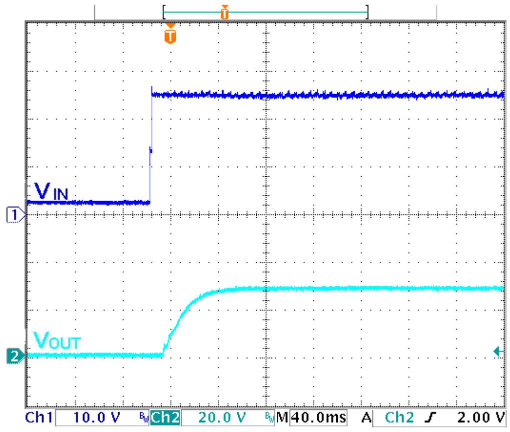
All test conditions are at 25°C. The figures are identical for TEP 160-2416WIR (continued)



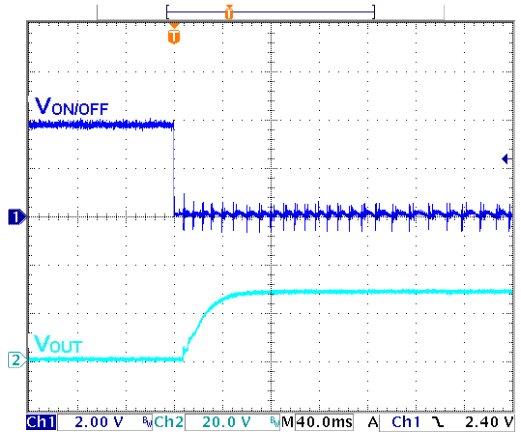
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



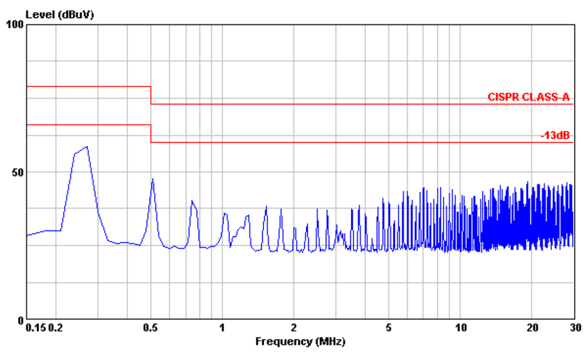
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



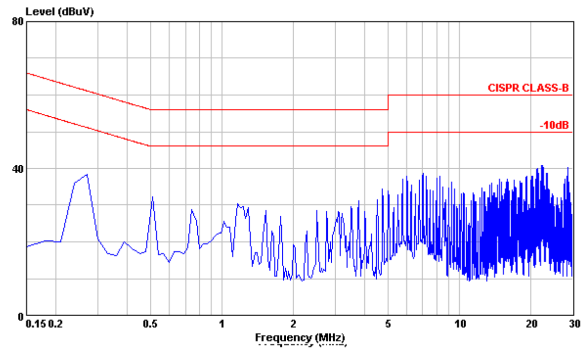
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



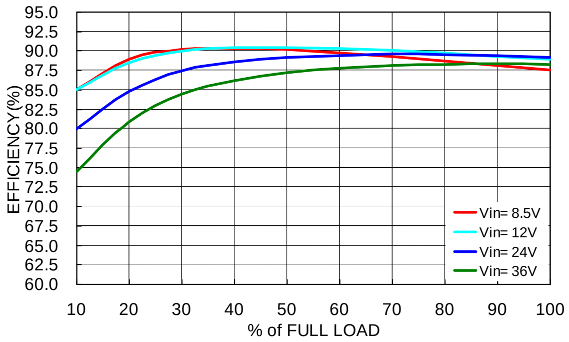
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



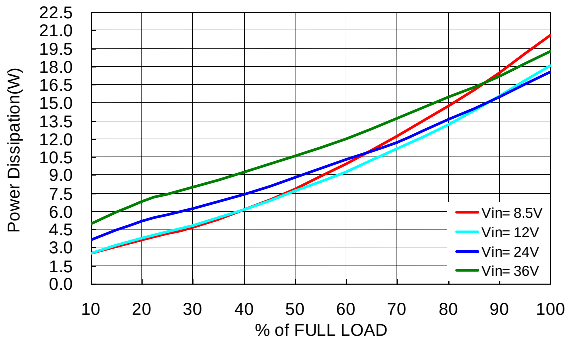
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

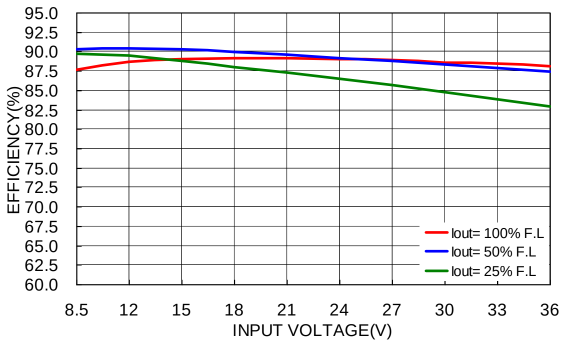
All test conditions are at 25°C. The figures are identical for TEP 160-2418WIR



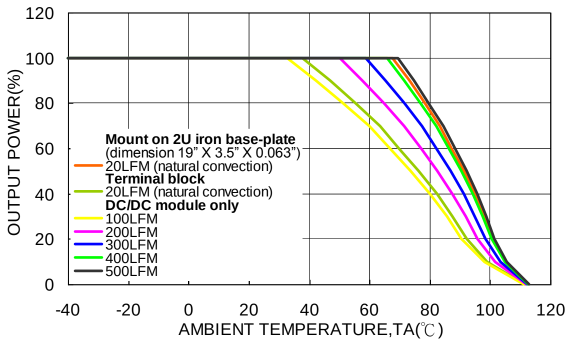
Efficiency versus Output Current



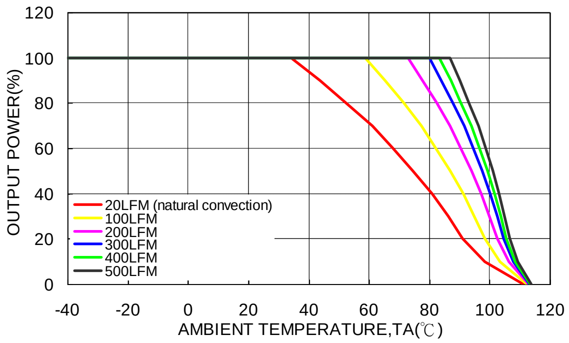
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



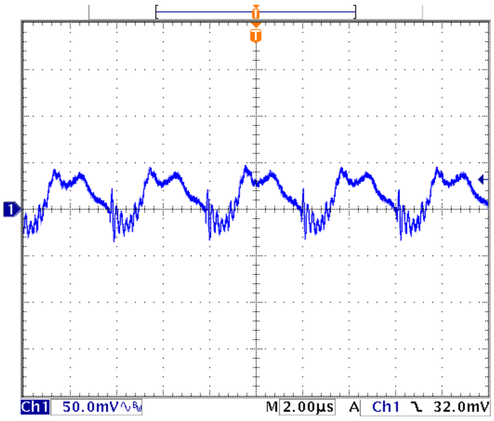
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



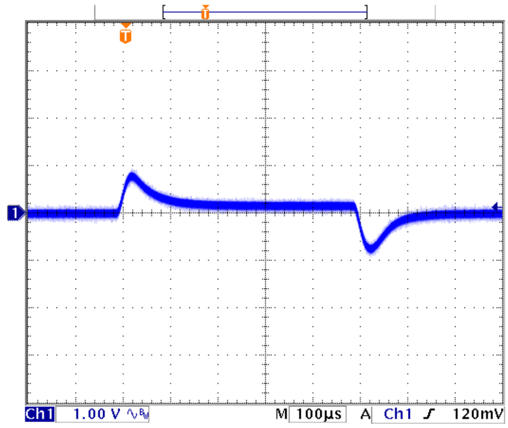
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

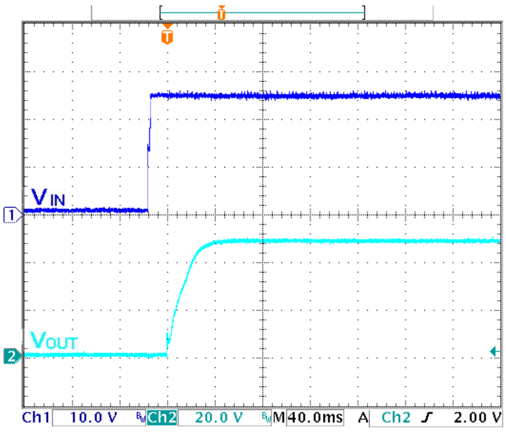
All test conditions are at 25°C. The figures are identical for TEP 160-2418WIR (continued)



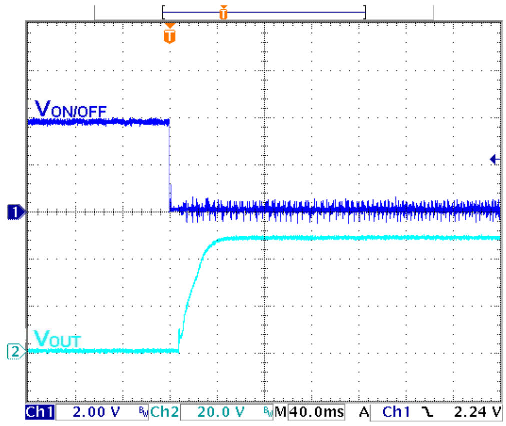
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



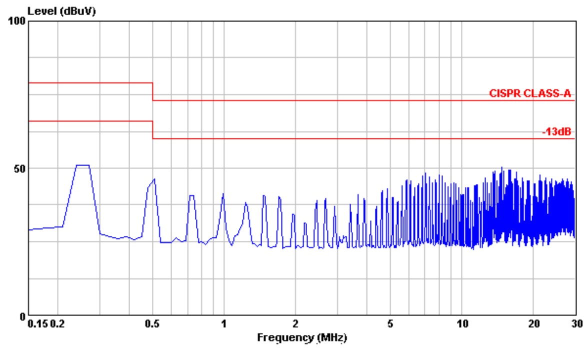
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



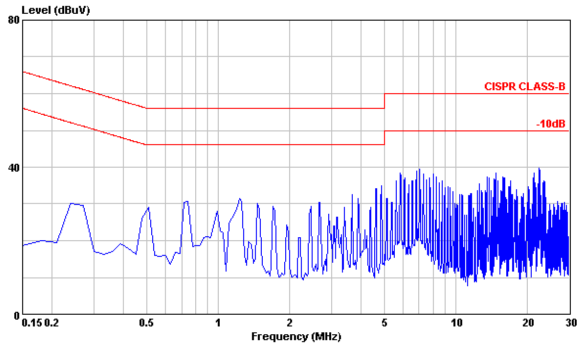
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



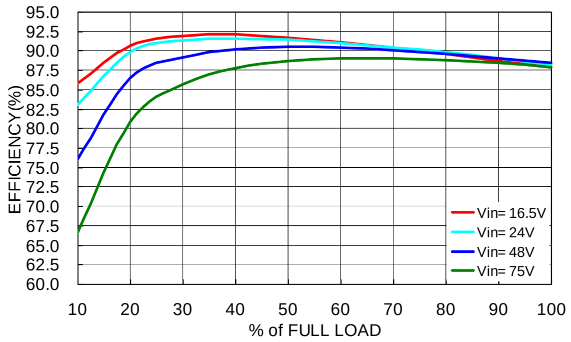
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



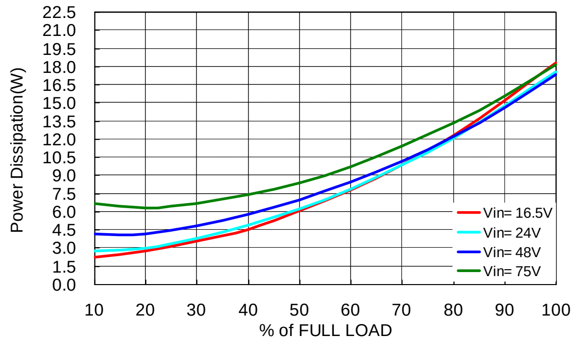
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

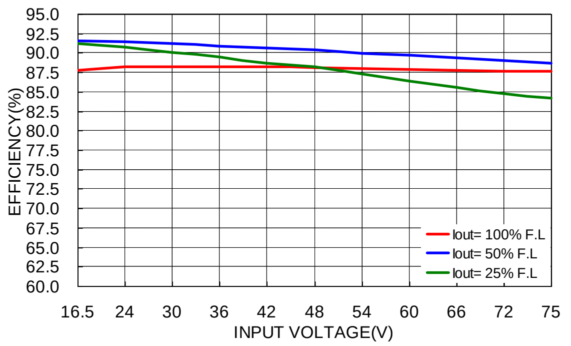
All test conditions are at 25°C. The figures are identical for TEP 160-4810WIR (order on demand)



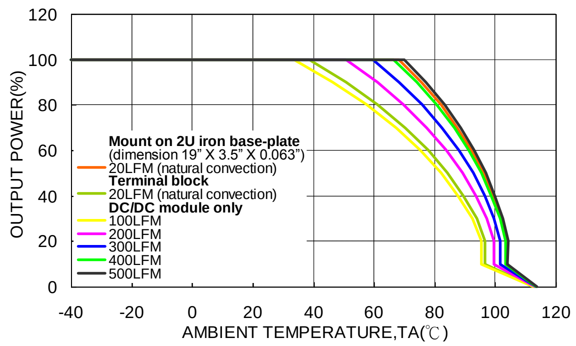
Efficiency versus Output Current



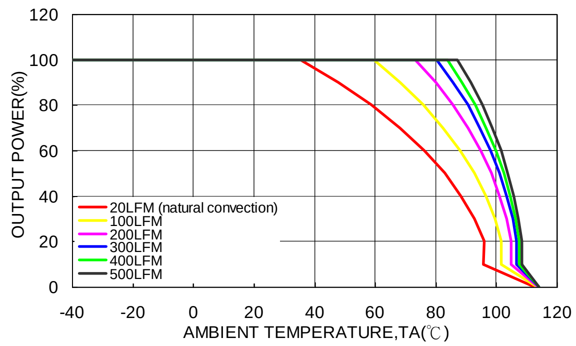
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



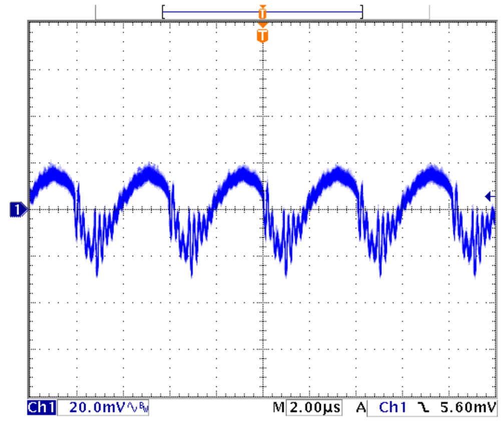
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



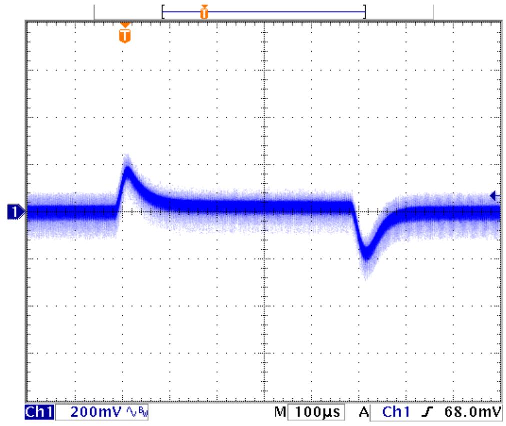
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

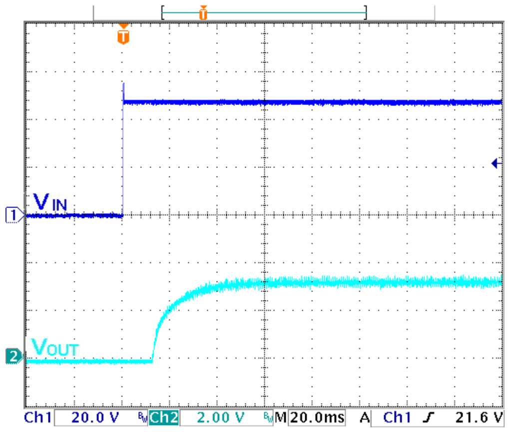
All test conditions are at 25°C. The figures are identical for TEP 160-4810WIR (continued)



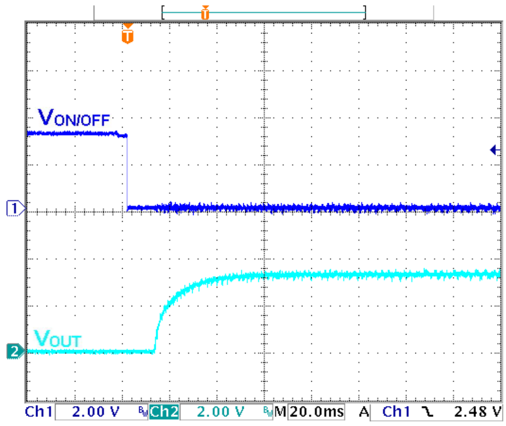
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



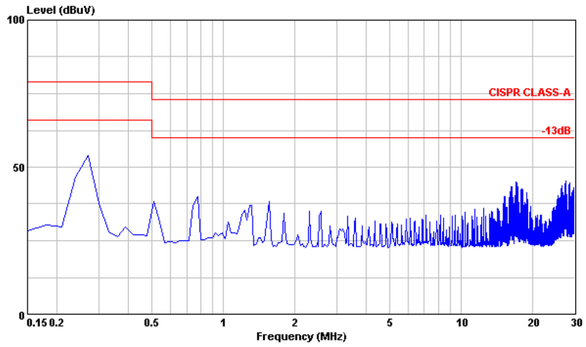
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



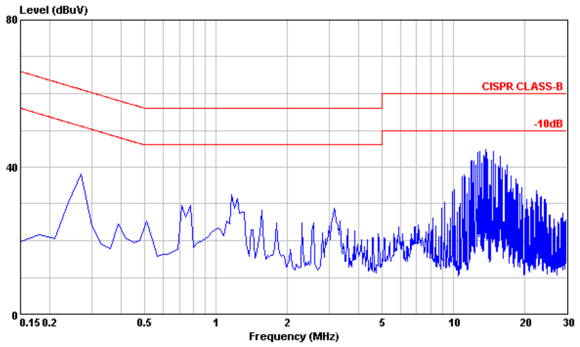
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



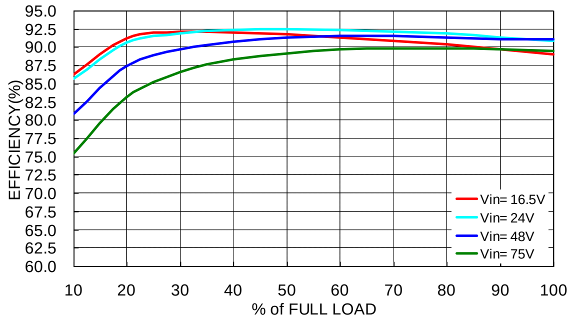
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



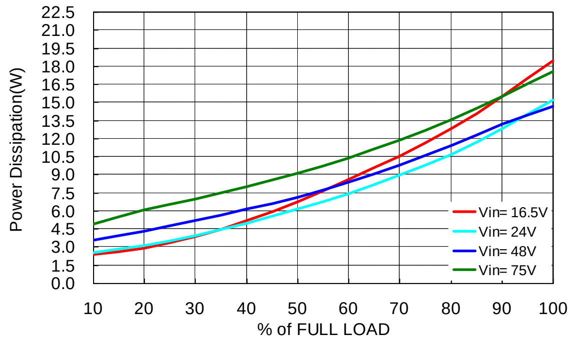
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

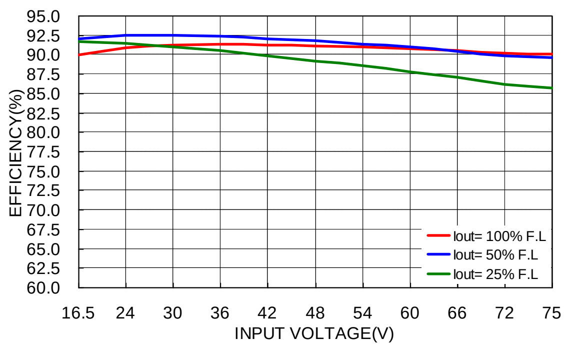
All test conditions are at 25°C. The figures are identical for TEP 160-4811WIR (order on demand)



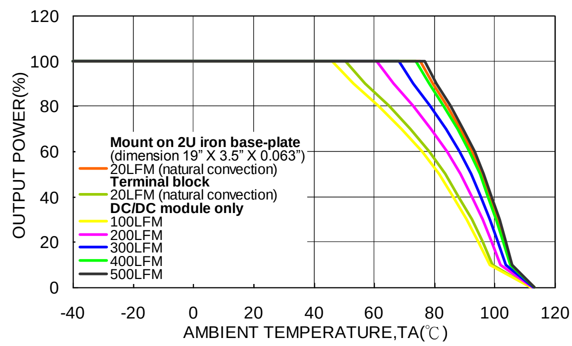
Efficiency versus Output Current



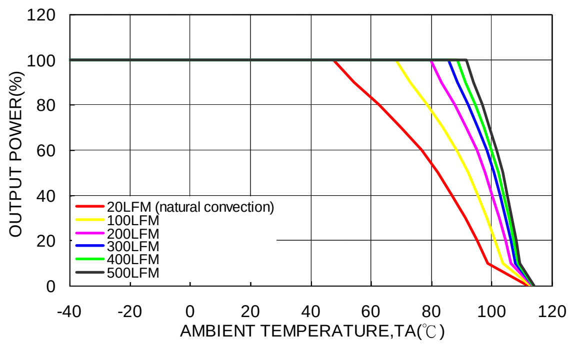
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



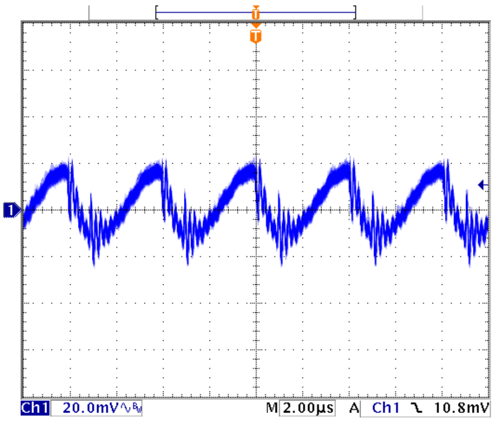
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



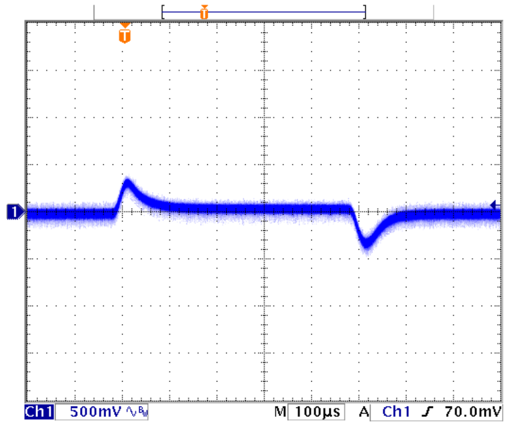
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

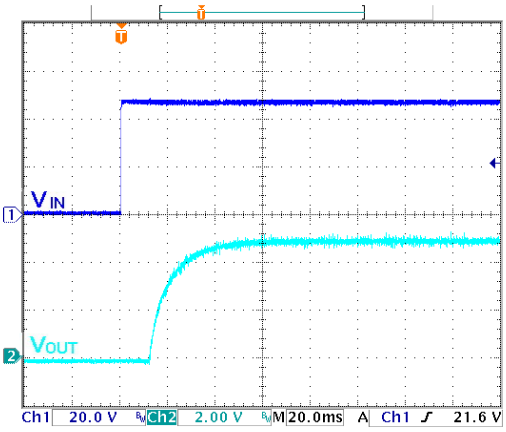
All test conditions are at 25°C. The figures are identical for TEP 160-4811WIR (continued)



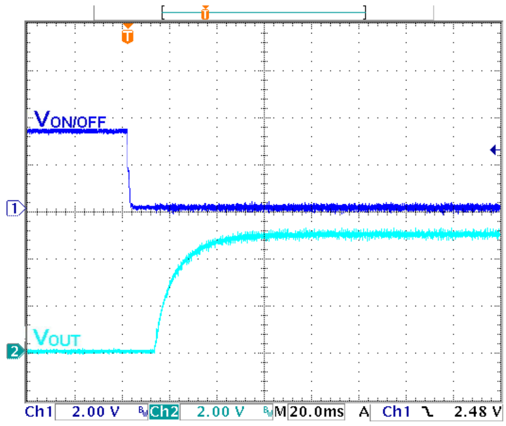
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



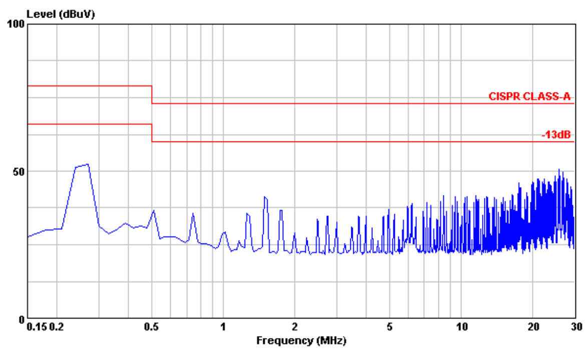
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



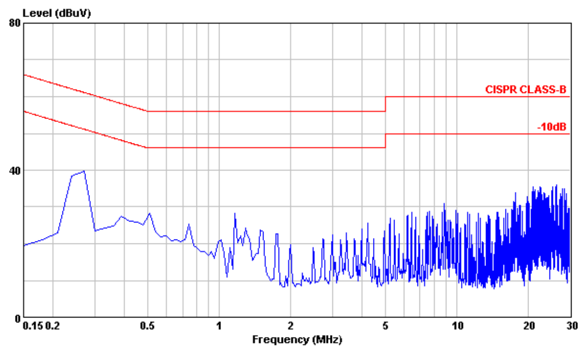
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



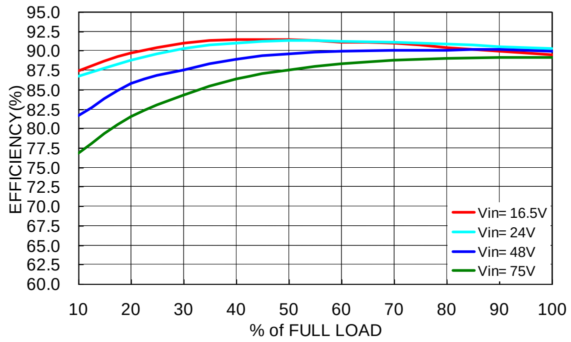
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



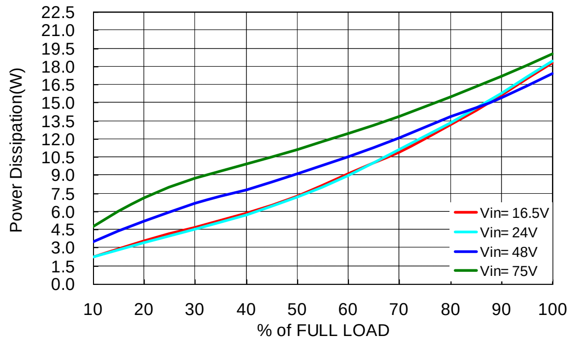
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

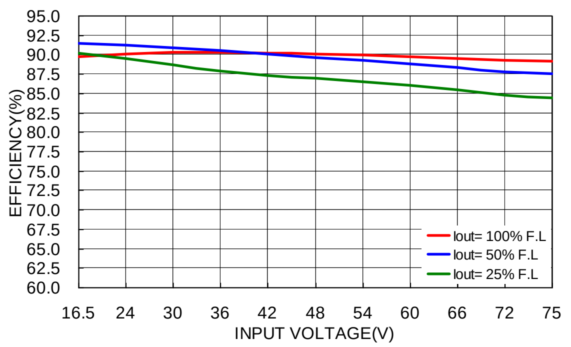
All test conditions are at 25°C. The figures are identical for TEP 160-4812WIR



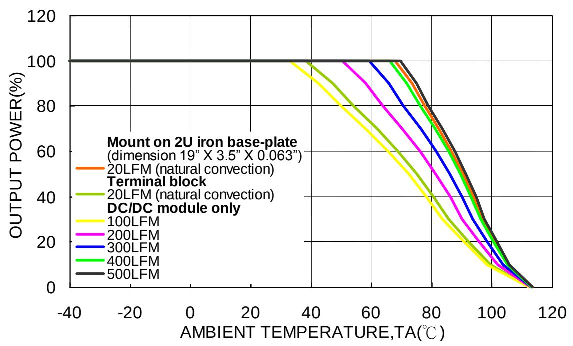
Efficiency versus Output Current



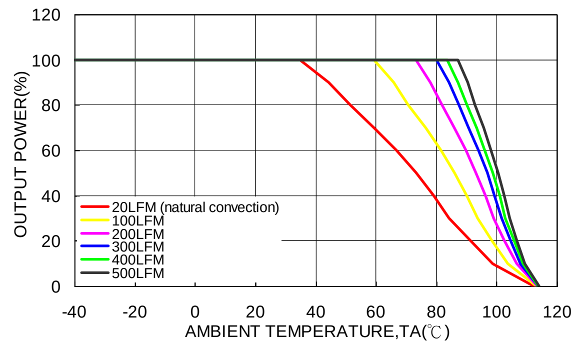
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



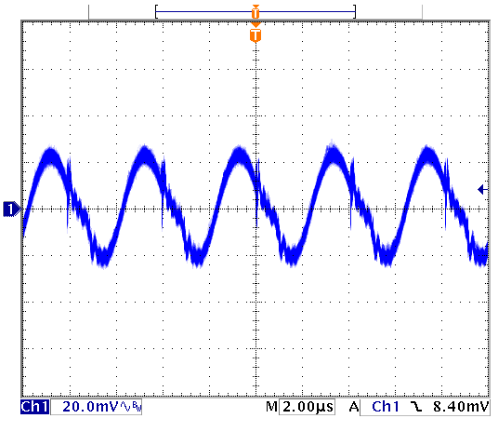
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



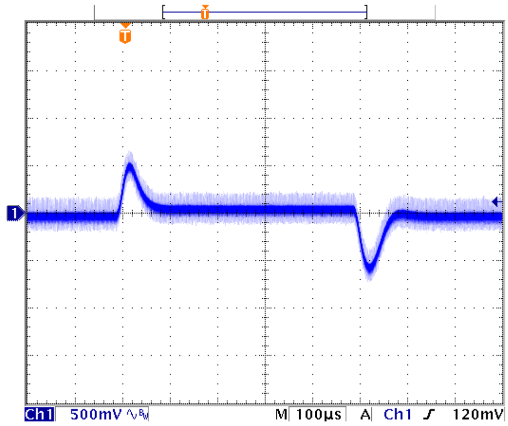
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

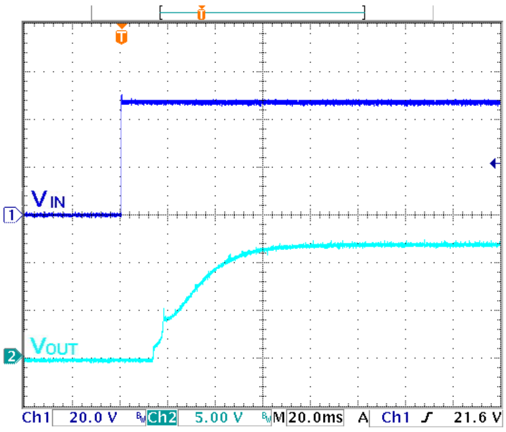
All test conditions are at 25°C. The figures are identical for TEP 160-4812WIR (continued)



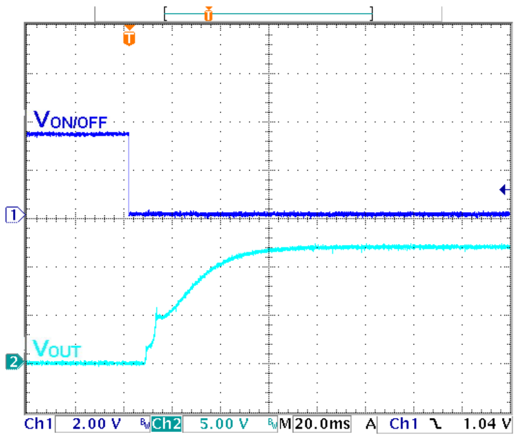
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



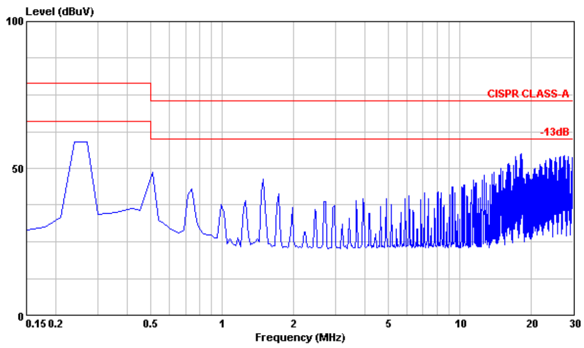
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



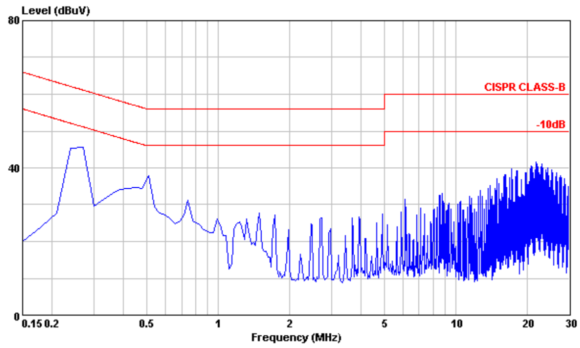
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



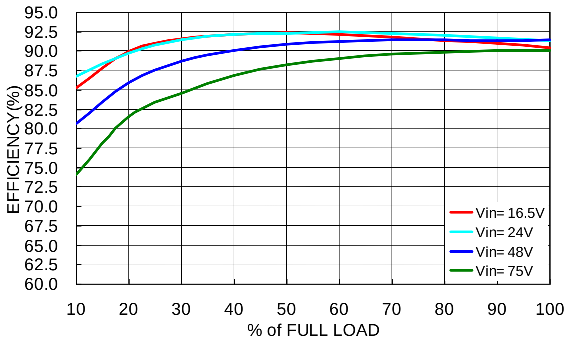
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



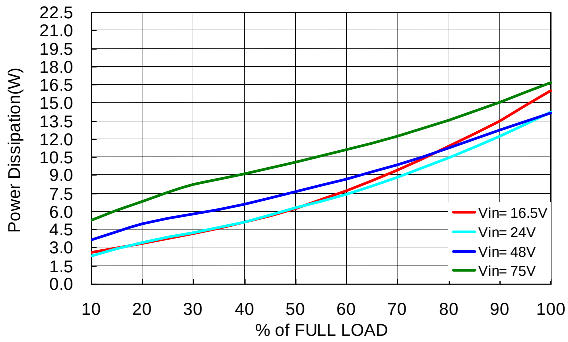
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curve

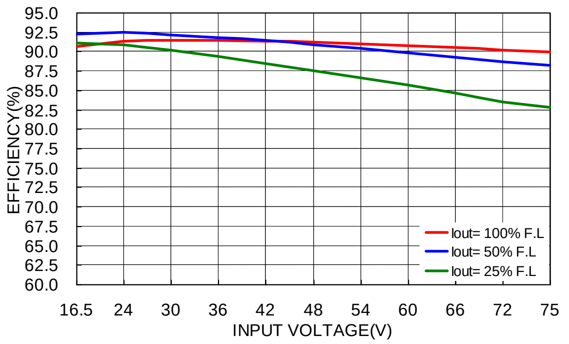
All test conditions are at 25°C. The figures are identical for TEP 160-4813WIR



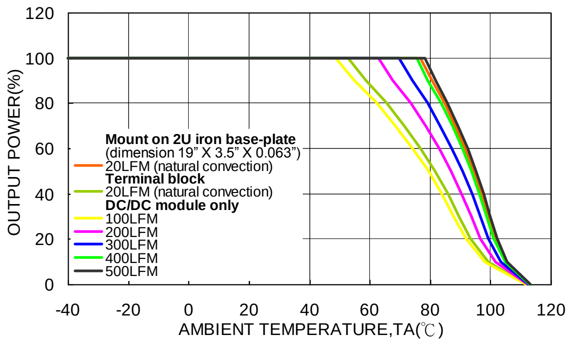
Efficiency versus Output Current



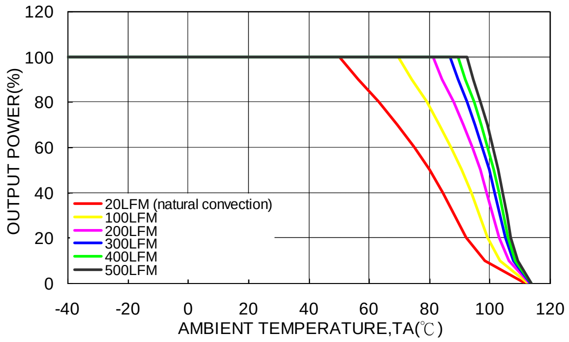
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



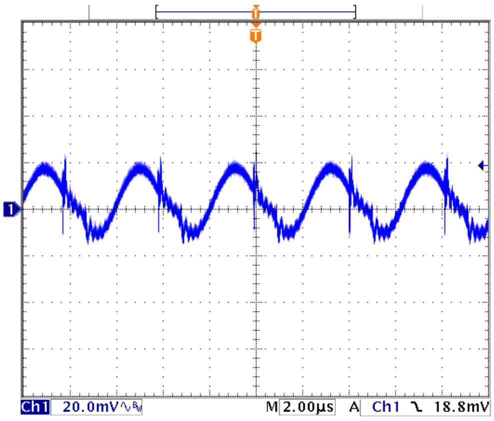
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



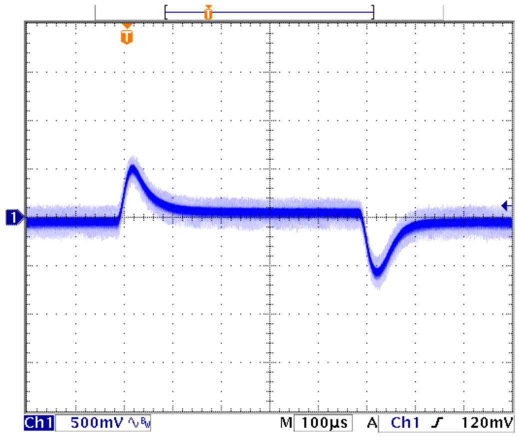
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

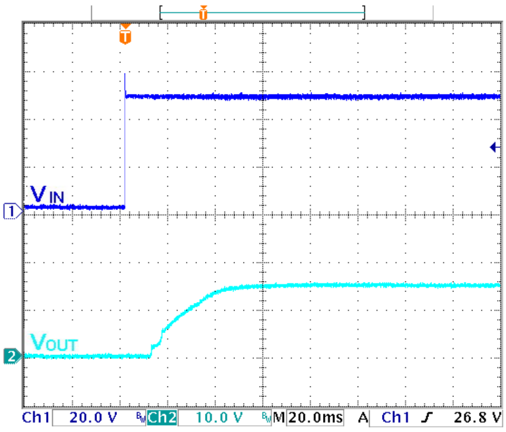
All test conditions are at 25°C. The figures are identical for TEP 160-4813WIR (continued)



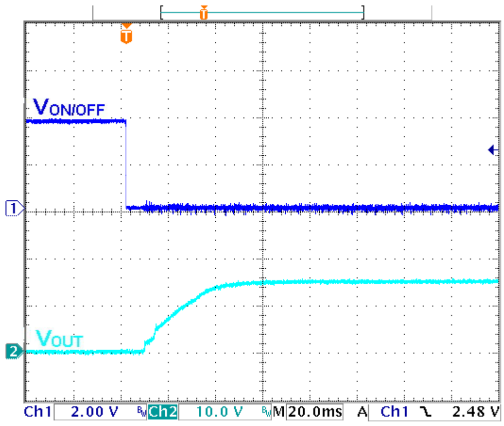
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



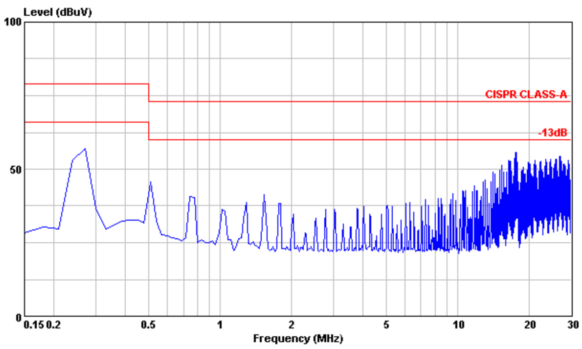
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



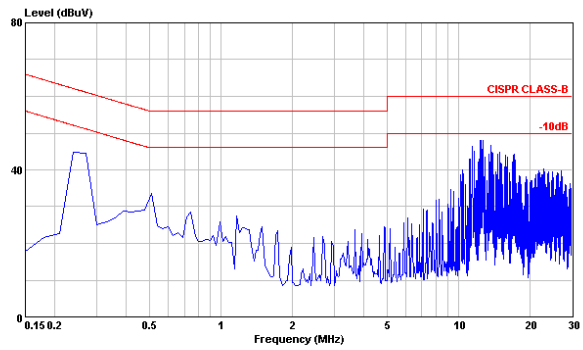
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



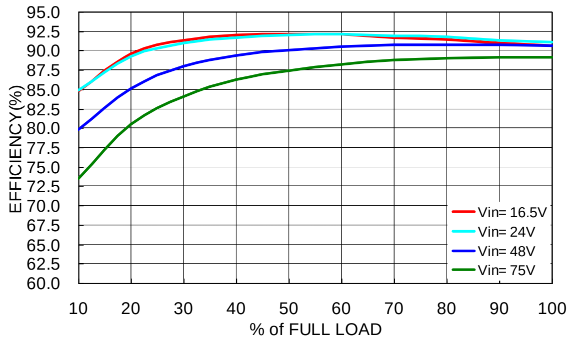
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



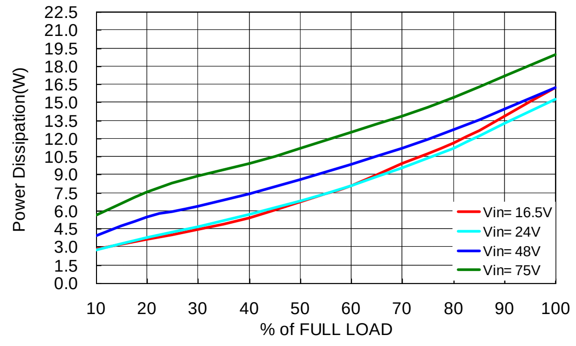
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

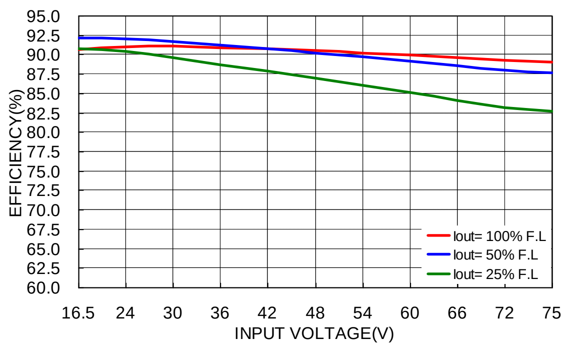
All test conditions are at 25°C. The figures are identical for TEP 160-4815WIR



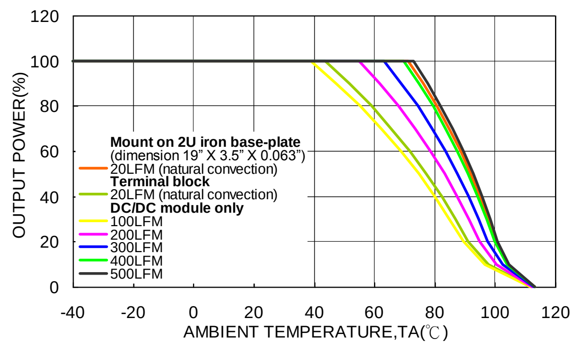
Efficiency versus Output Current



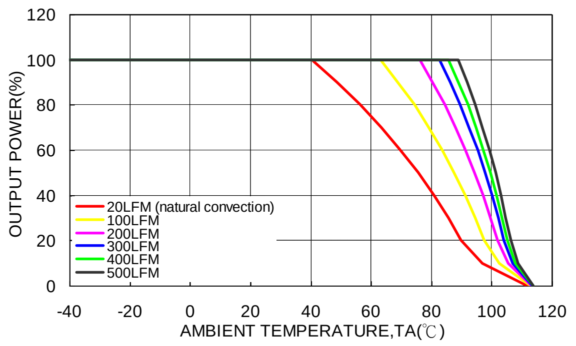
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



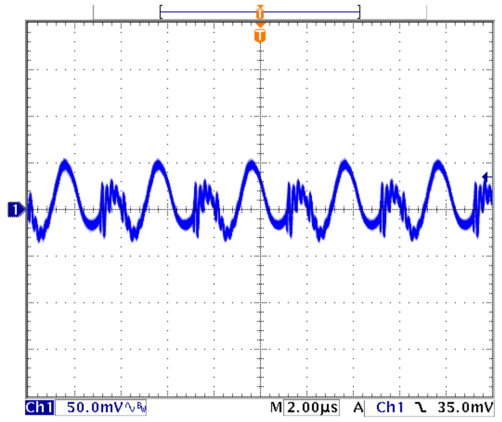
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



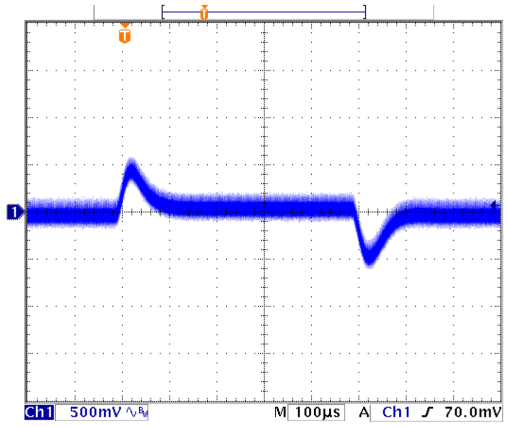
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

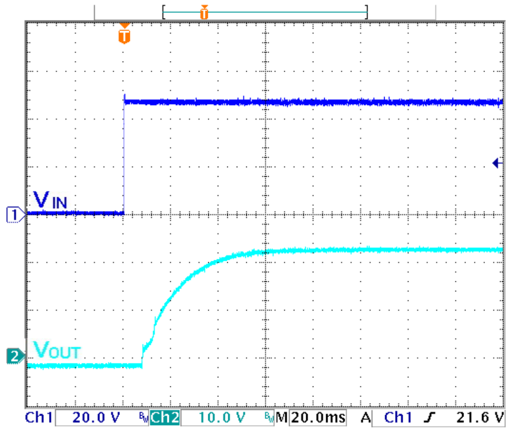
All test conditions are at 25°C. The figures are identical for TEP 160-4815WIR (continued)



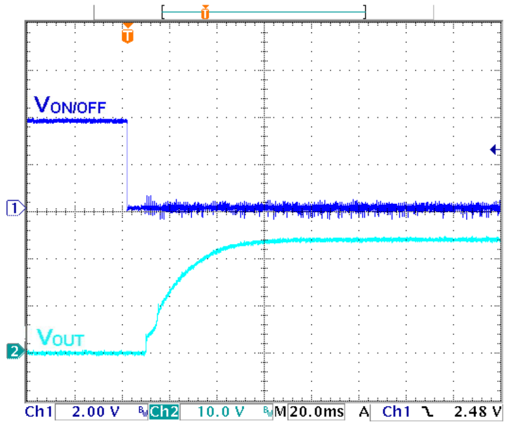
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



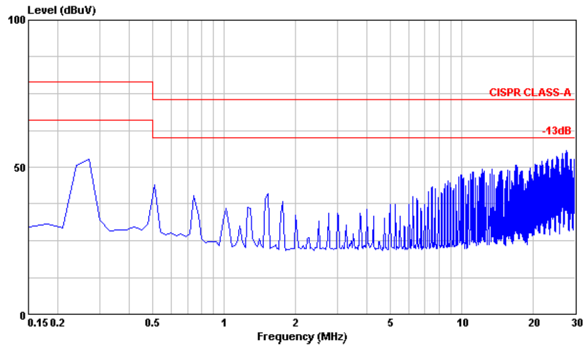
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



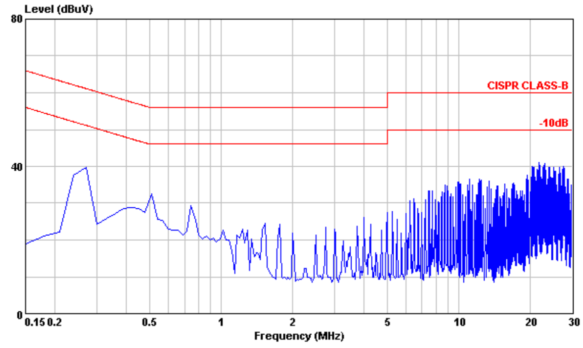
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



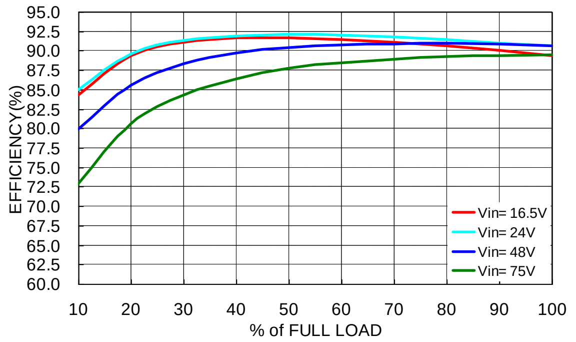
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



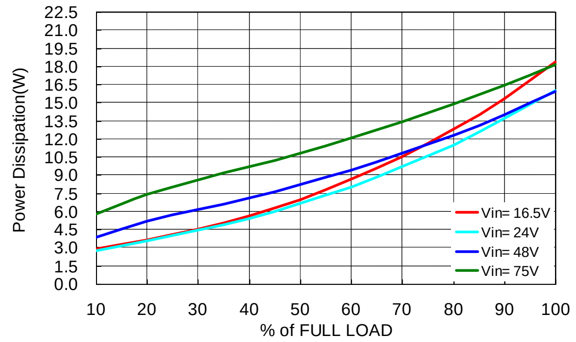
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

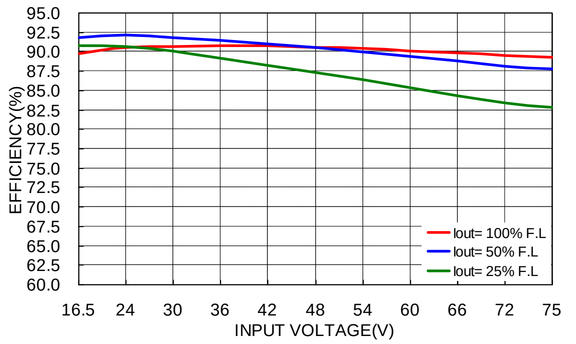
All test conditions are at 25°C. The figures are identical for TEP 160-4816WIR



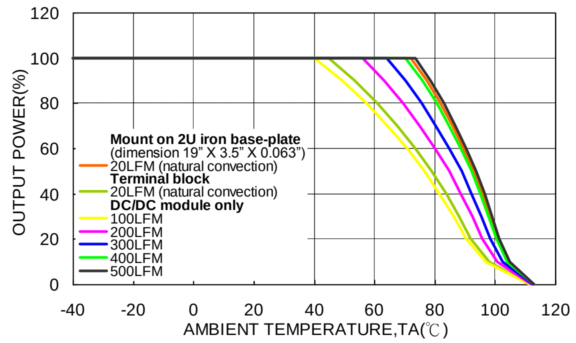
Efficiency versus Output Current



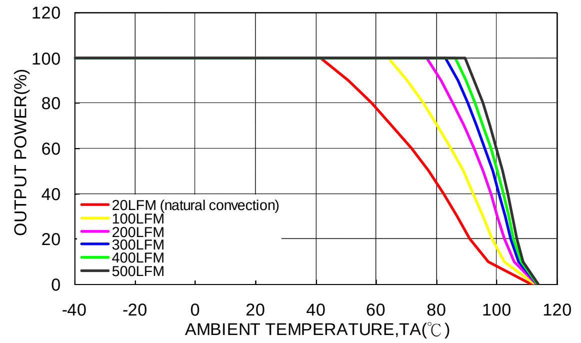
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



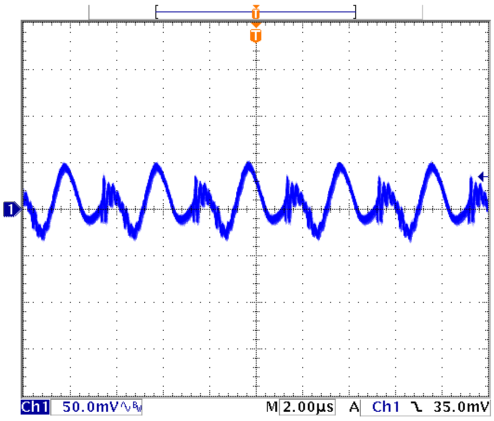
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



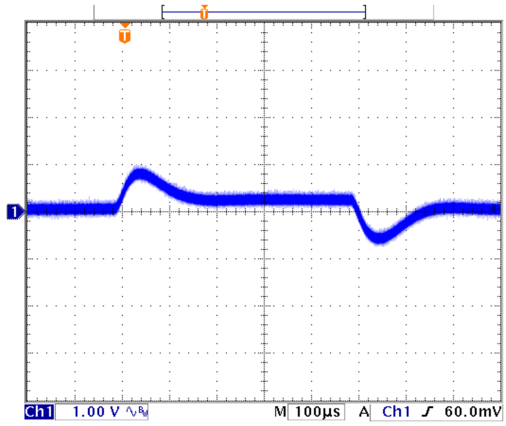
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

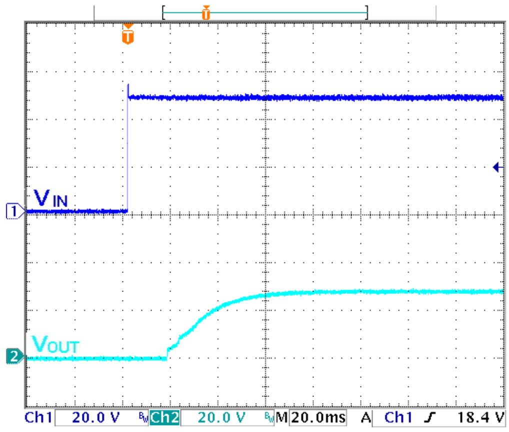
All test conditions are at 25°C. The figures are identical for TEP 160-4816WIR (continued)



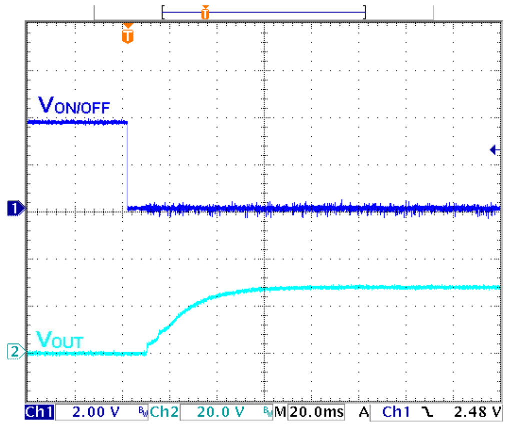
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



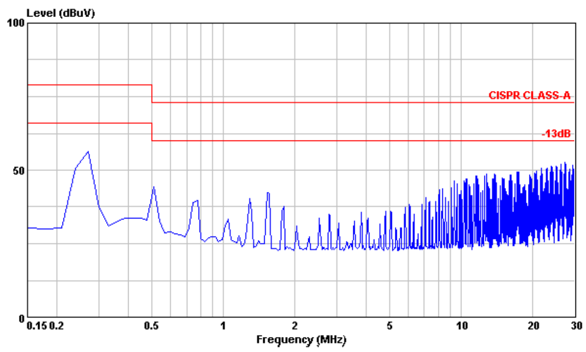
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



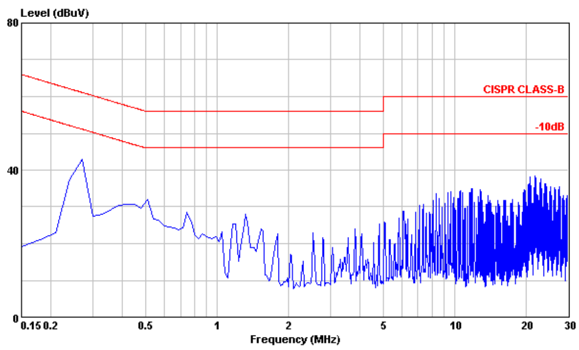
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



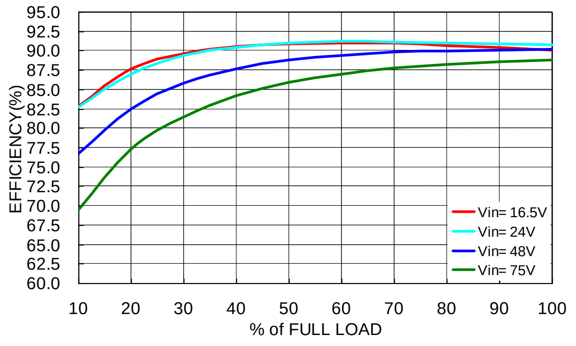
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



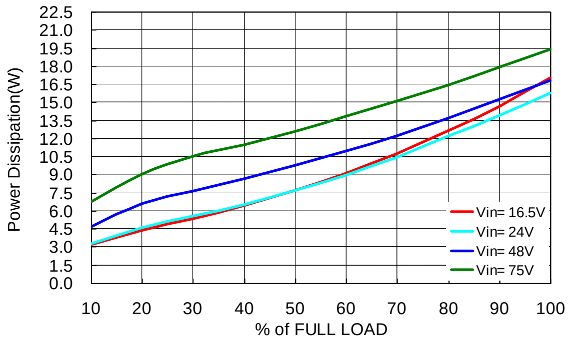
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

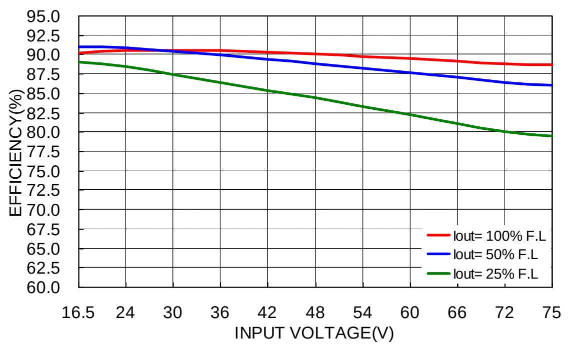
All test conditions are at 25°C. The figures are identical for TEP 160-4818WIR



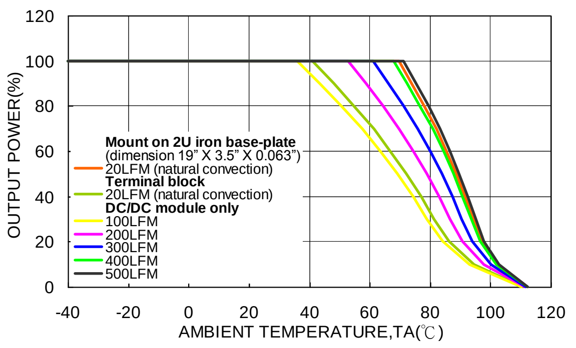
Efficiency versus Output Current



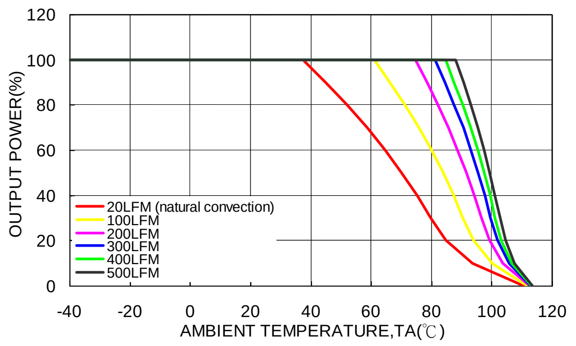
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



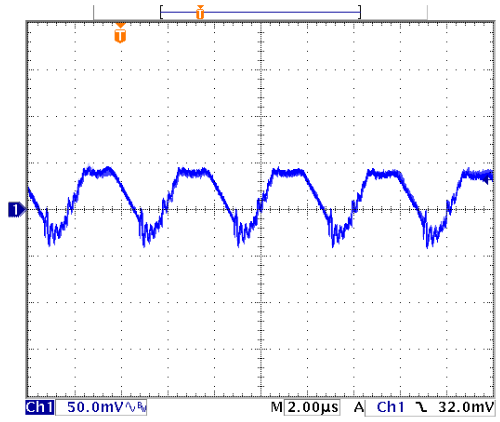
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



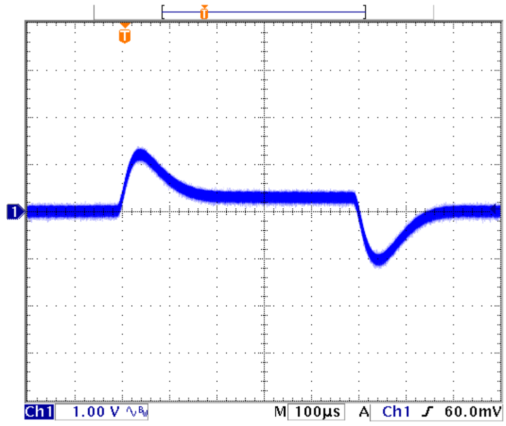
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

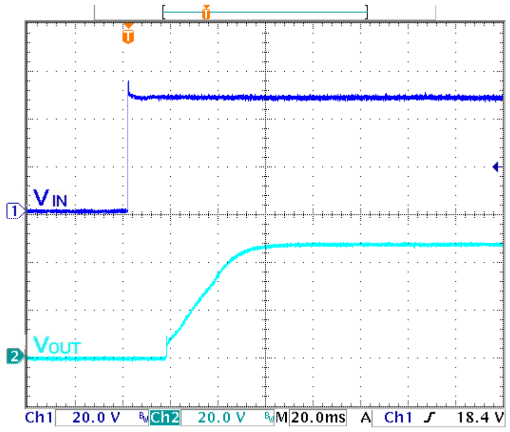
All test conditions are at 25°C. The figures are identical for TEP 160-4818WIR (continued)



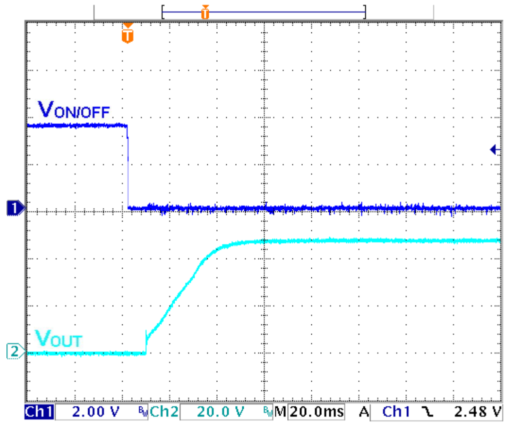
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



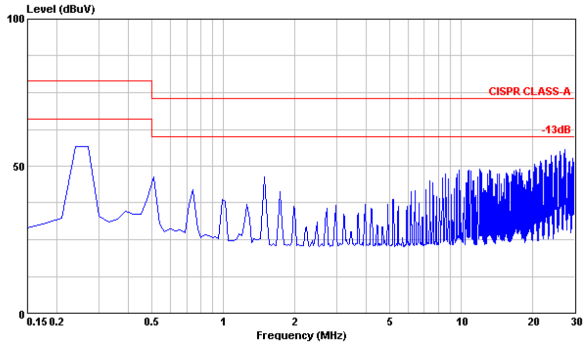
Transient Response to Dynamic Load Change from
100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



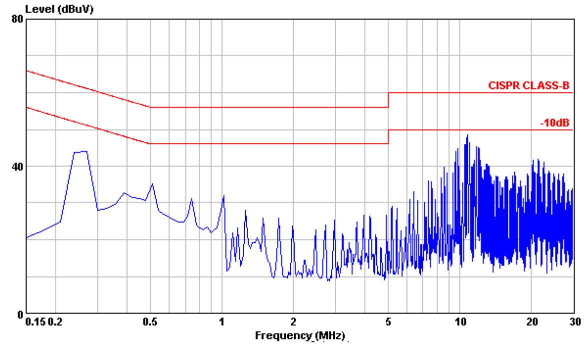
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



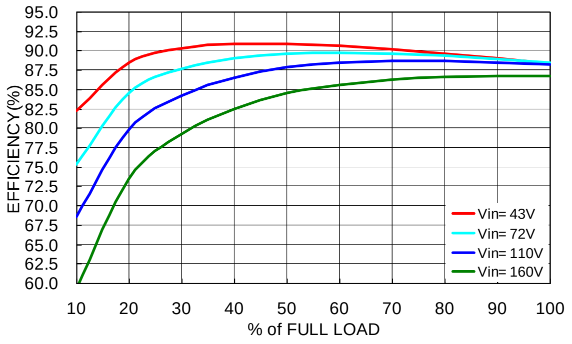
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



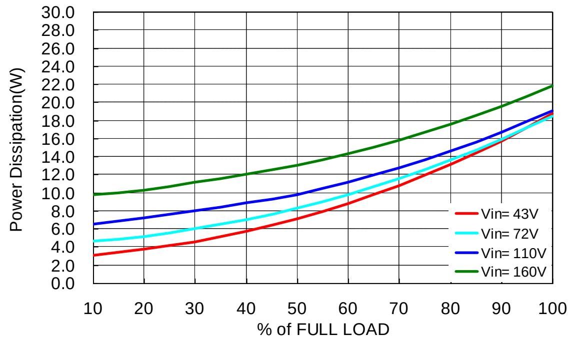
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

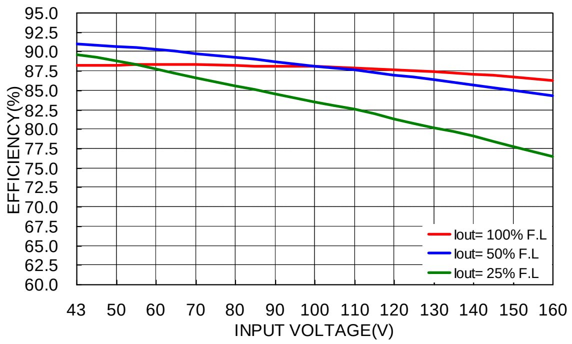
All test conditions are at 25°C. The figures are identical for TEP 160-7210WIR (order on demand)



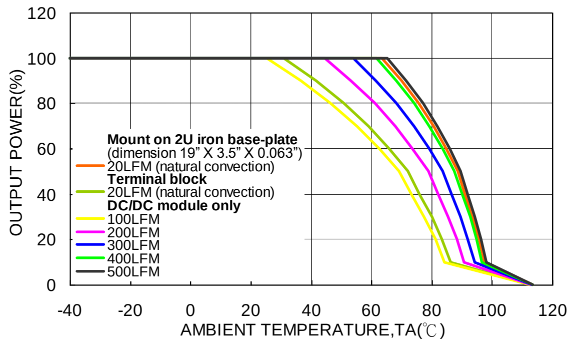
Efficiency versus Output Current



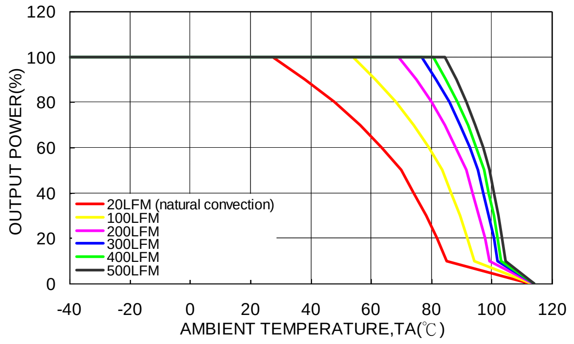
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



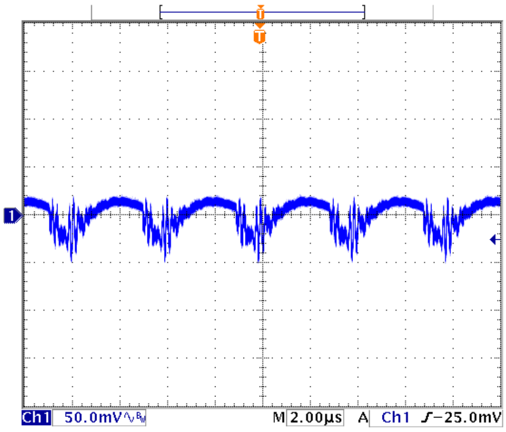
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



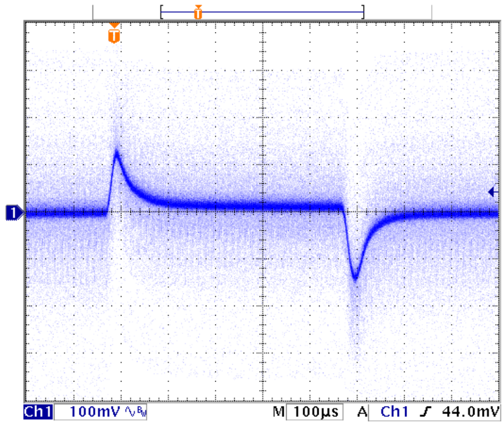
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

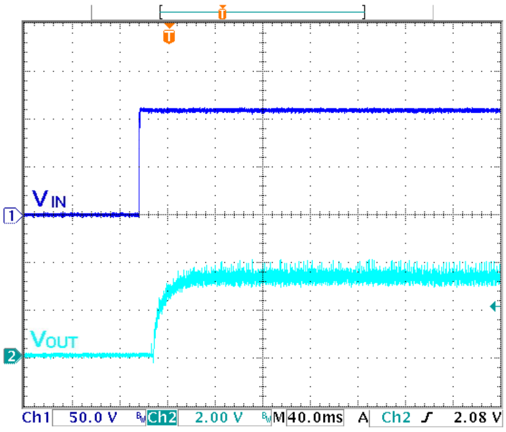
All test conditions are at 25°C. The figures are identical for TEP 160-7210WIR (continued)



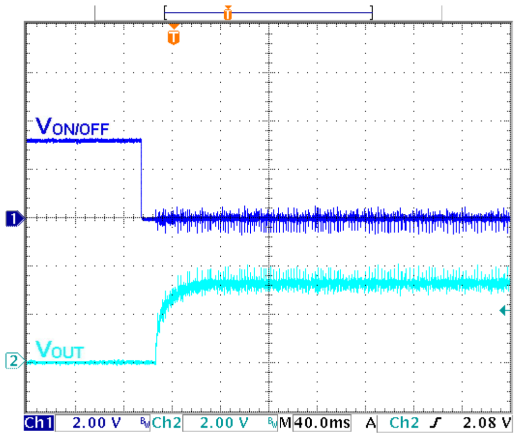
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



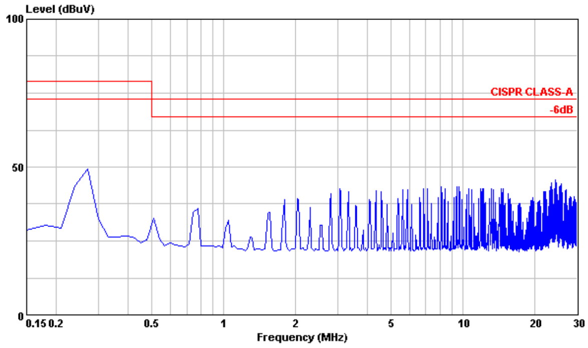
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



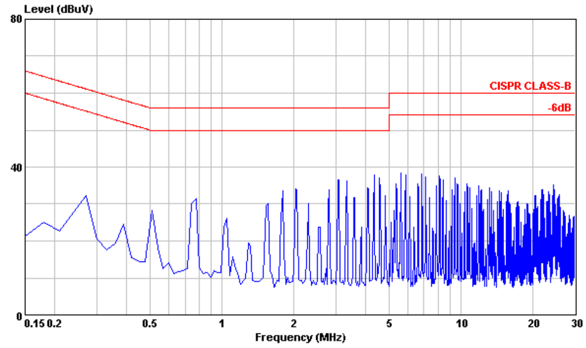
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



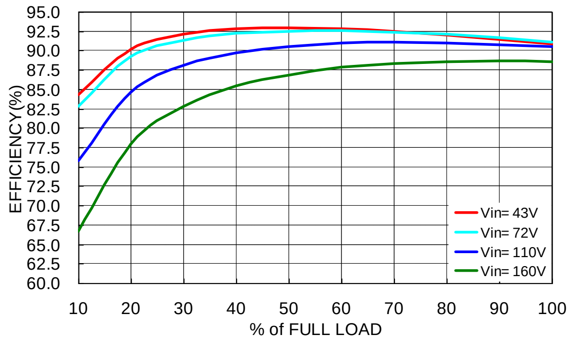
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



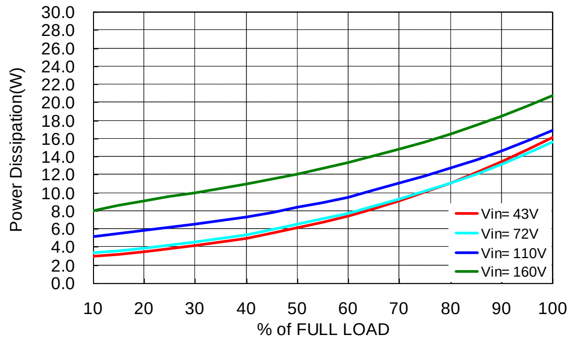
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

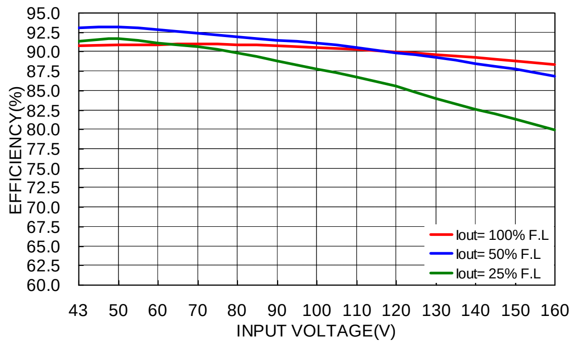
All test conditions are at 25°C. The figures are identical for TEP 160-7211WIR (order on demand)



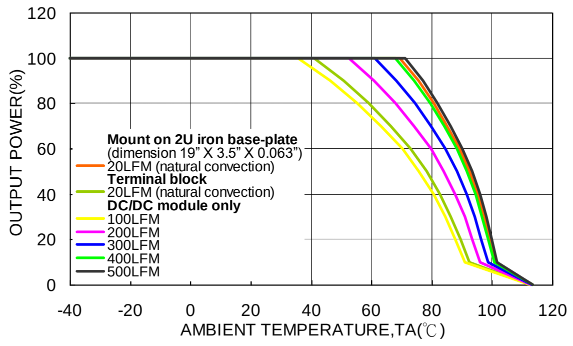
Efficiency versus Output Current



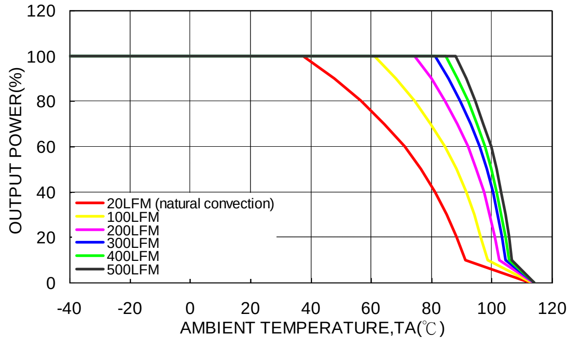
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



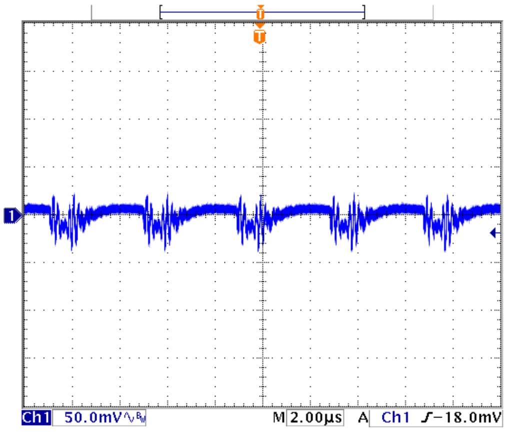
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



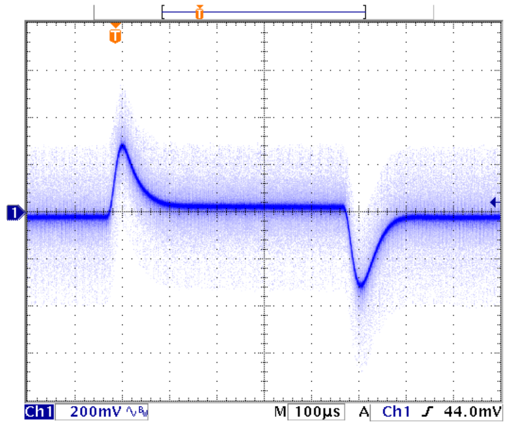
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

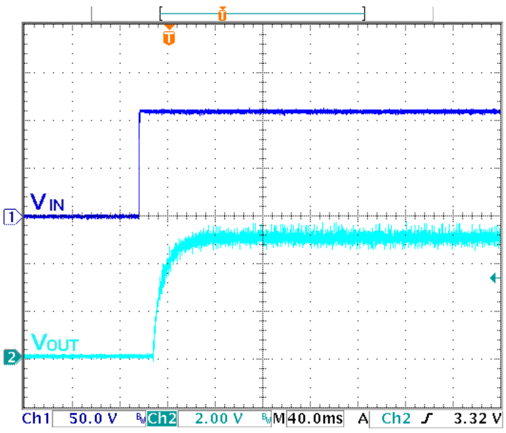
All test conditions are at 25°C. The figures are identical for TEP 160-7211WIR (continued)



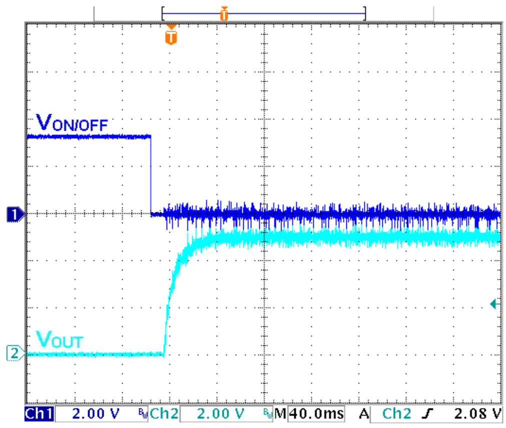
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



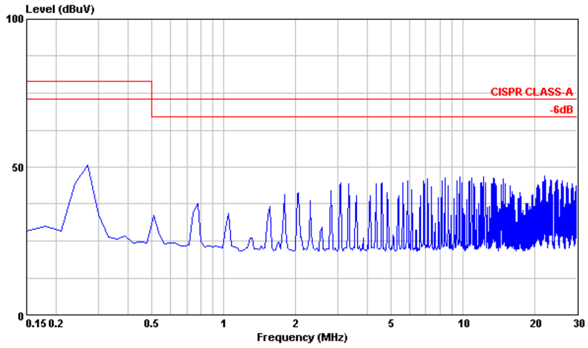
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



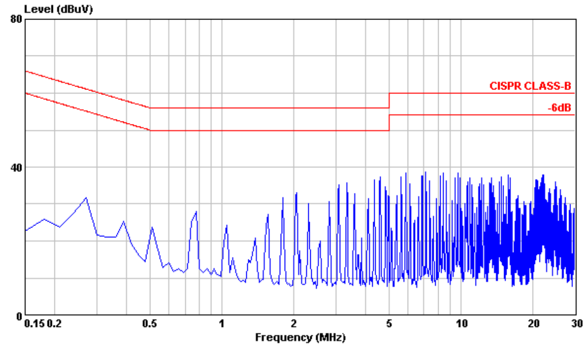
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



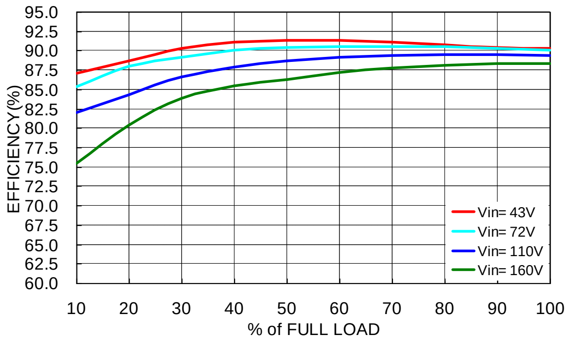
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



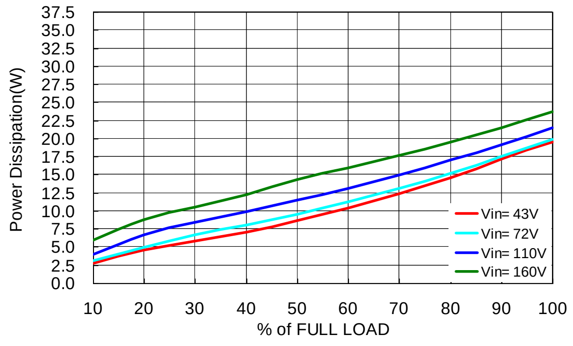
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

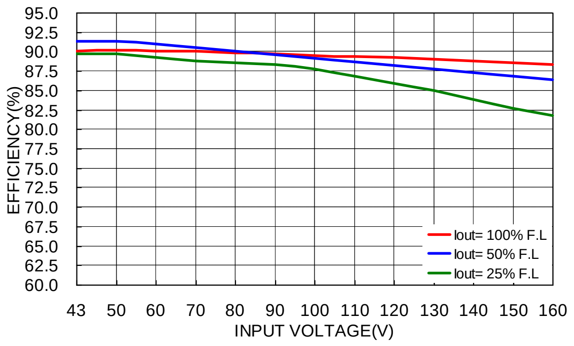
All test conditions are at 25°C. The figures are identical for TEP 160-7212WIR



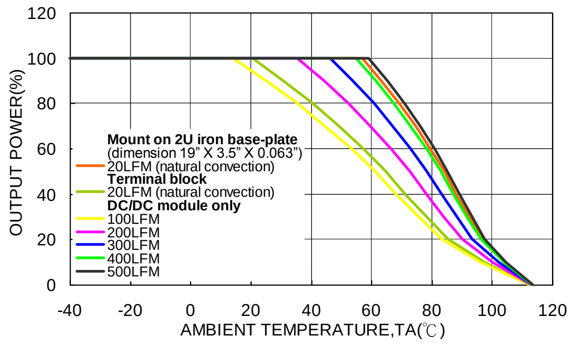
Efficiency versus Output Current



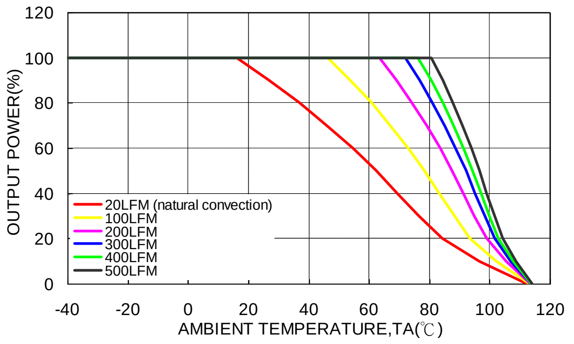
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



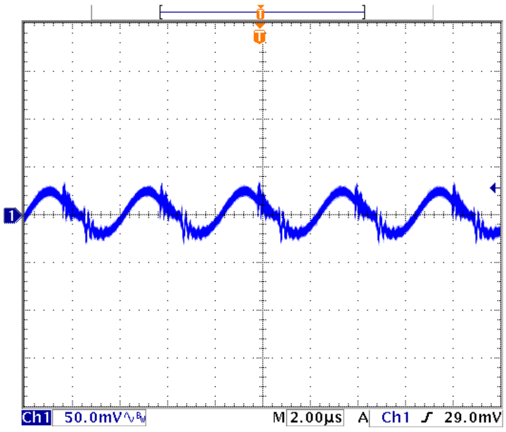
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



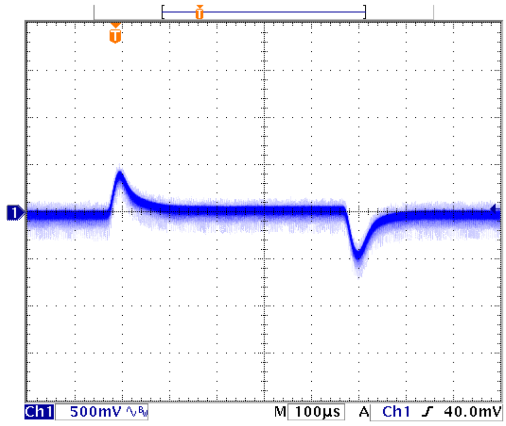
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

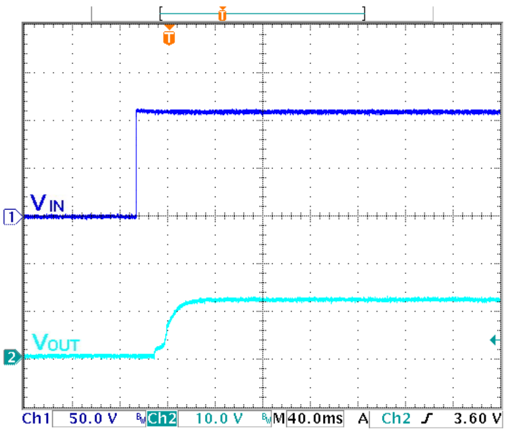
All test conditions are at 25°C. The figures are identical for TEP 160-7212WIR (continued)



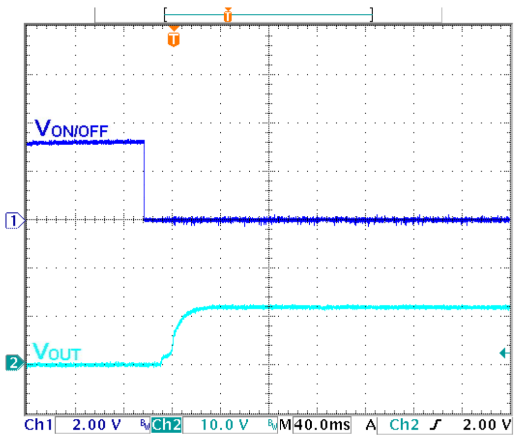
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



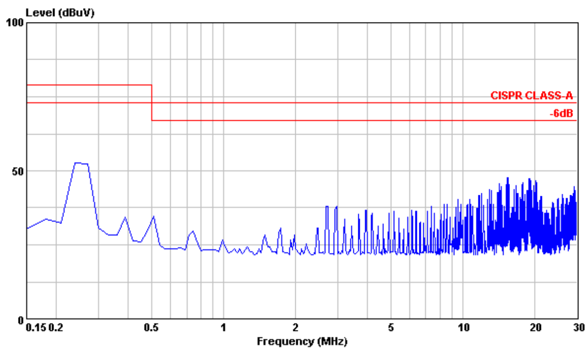
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



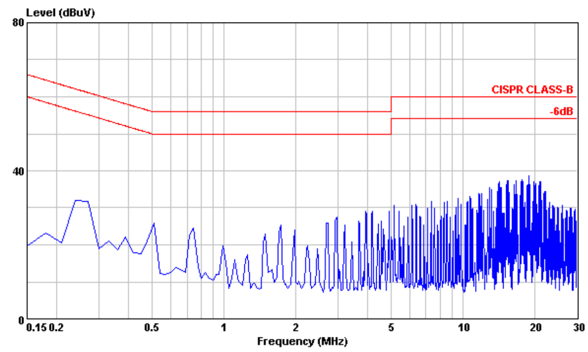
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



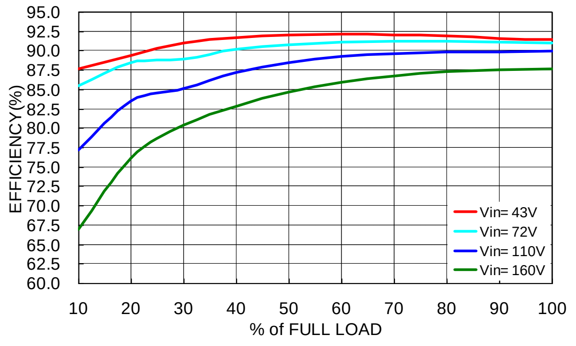
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



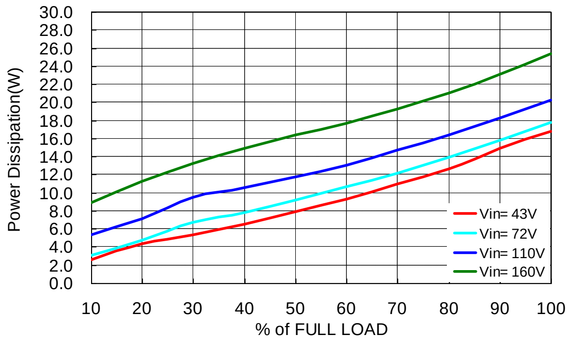
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

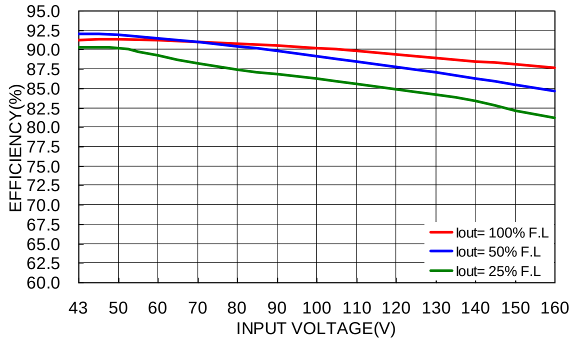
All test conditions are at 25°C. The figures are identical for TEP 160-7213WIR



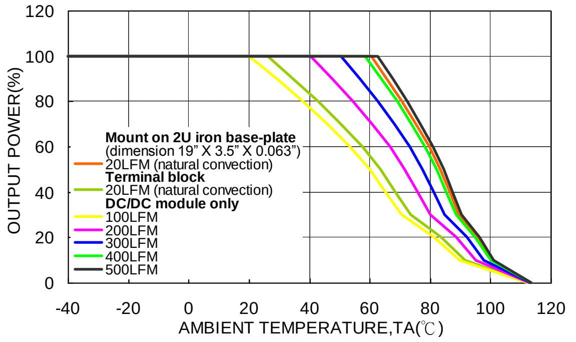
Efficiency versus Output Current



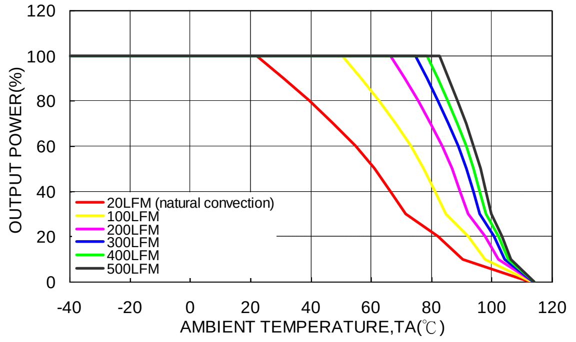
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



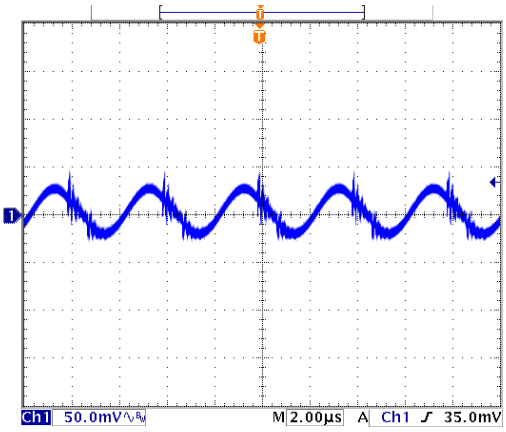
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



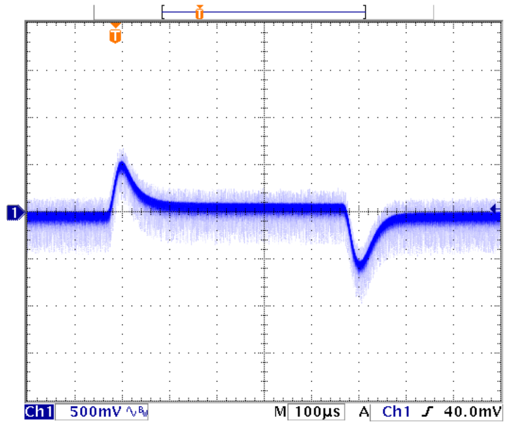
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

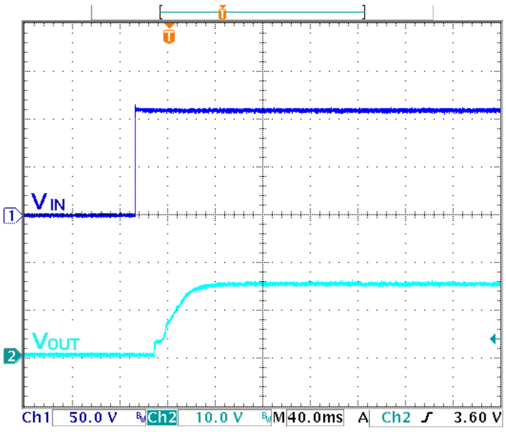
All test conditions are at 25°C. The figures are identical for TEP 160-7213WIR (continued)



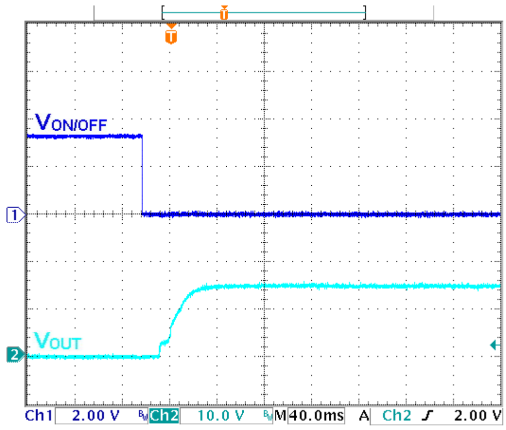
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



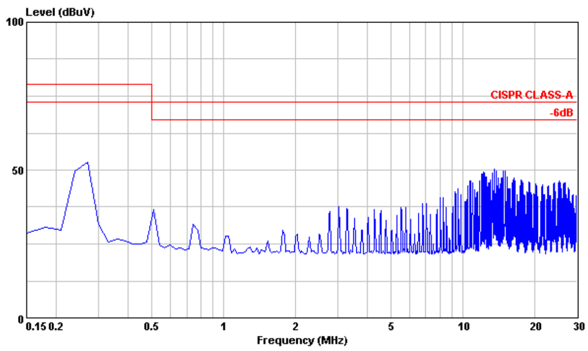
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



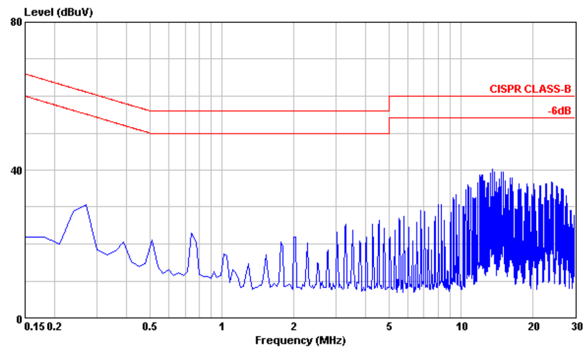
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



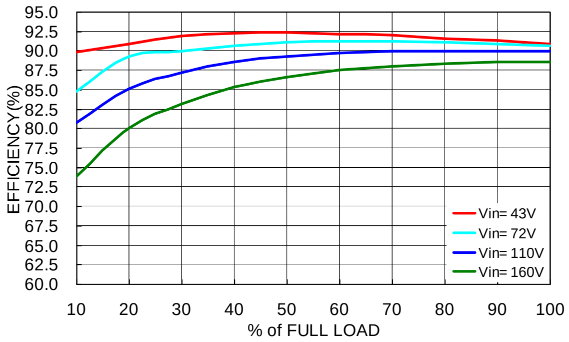
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



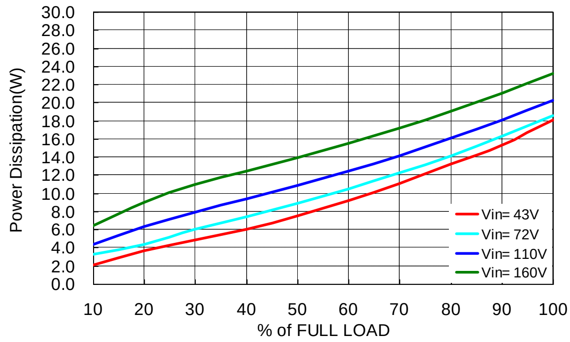
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

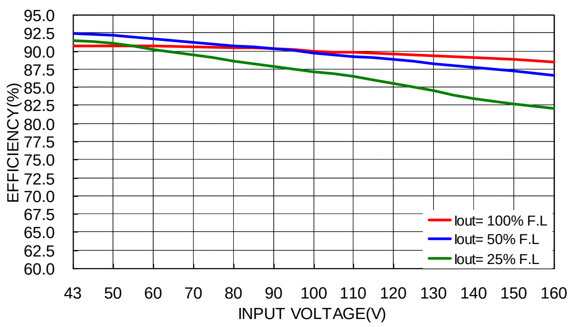
All test conditions are at 25°C. The figures are identical for TEP 160-7215WIR



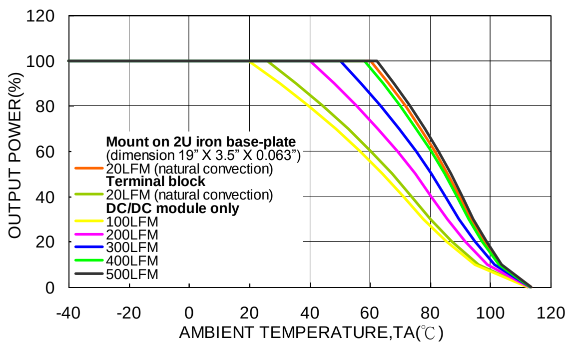
Efficiency versus Output Current



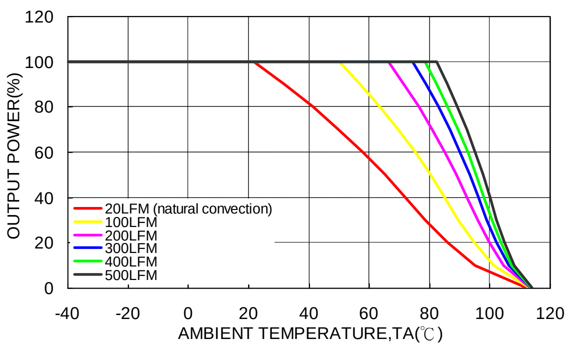
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



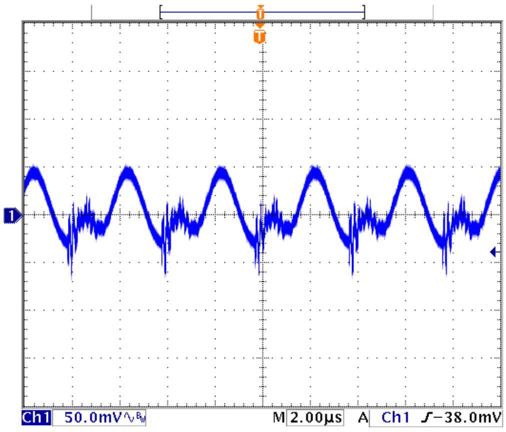
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\,nom}$



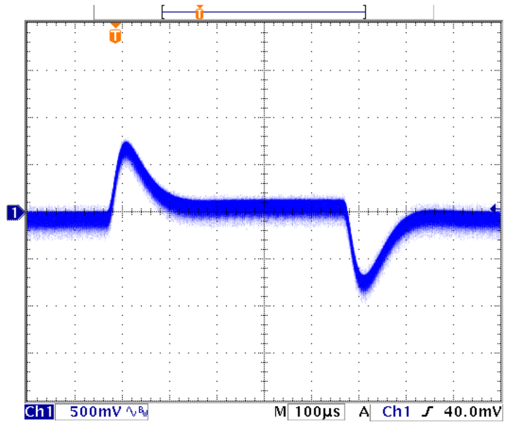
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\,nom}$

Characteristic Curves

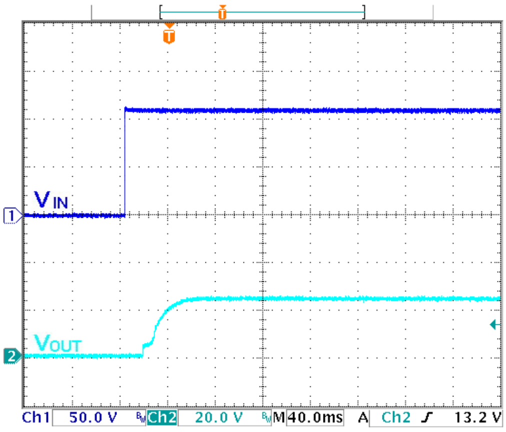
All test conditions are at 25°C. The figures are identical for TEP 160-7215WIR (continued)



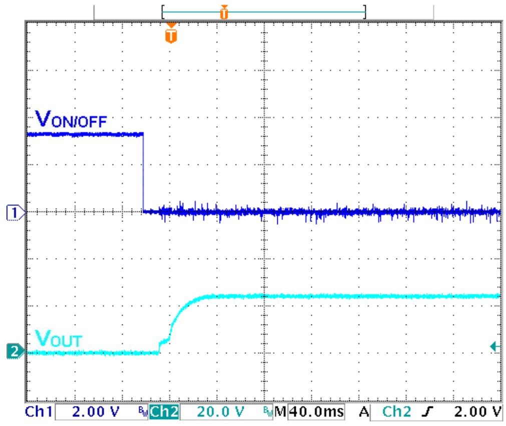
Typical Output Ripple and Noise.
$V_{in} = V_{in\,nom}$, Full Load



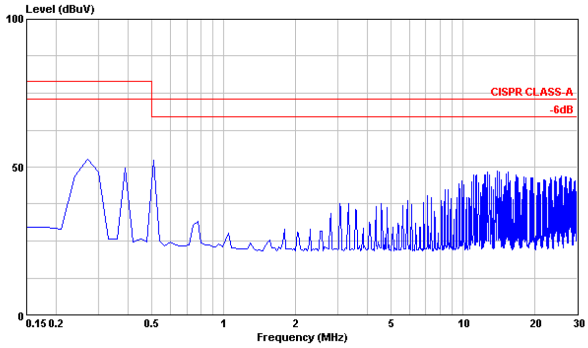
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\,nom}$



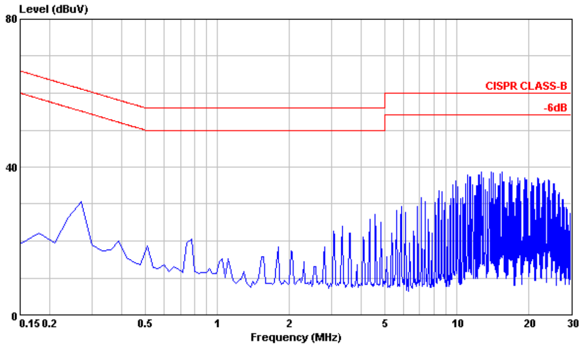
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\,nom}$, Full Load



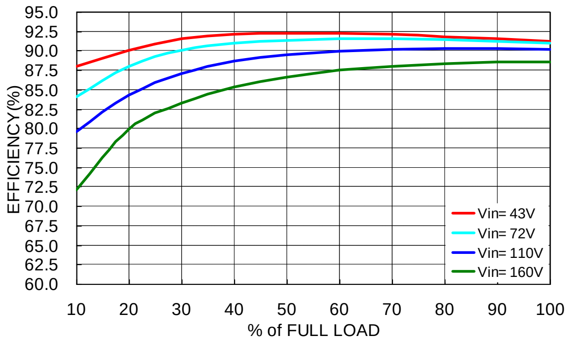
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\,nom}$, Full Load



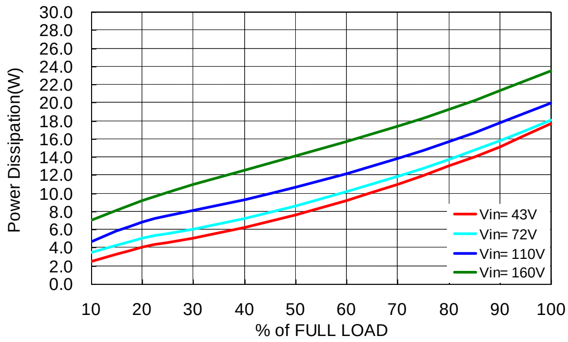
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\,nom}$, Full Load

Characteristic Curves

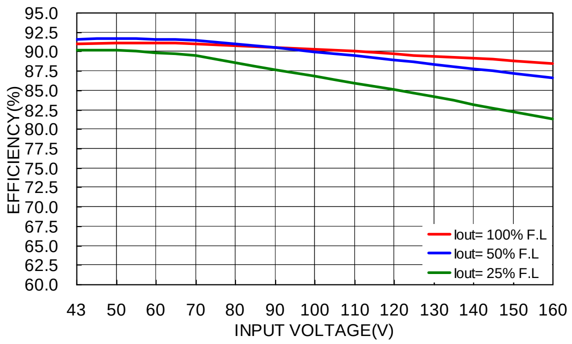
All test conditions are at 25°C. The figures are identical for TEP 160-7216WIR



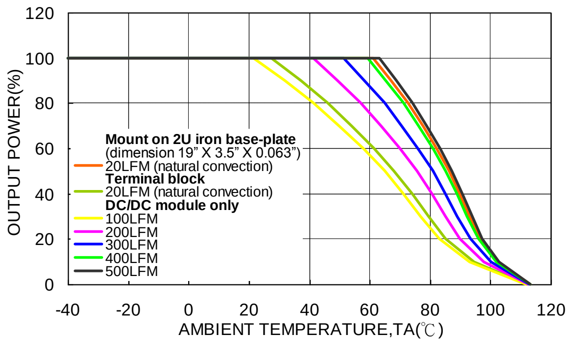
Efficiency versus Output Current



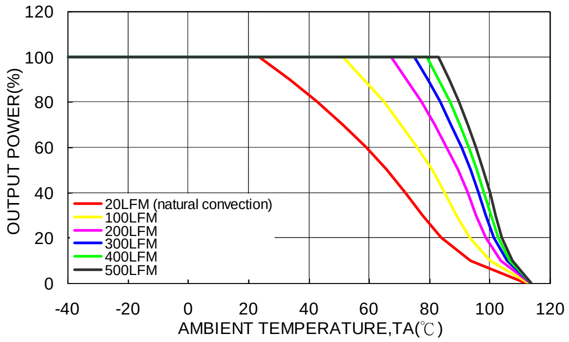
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



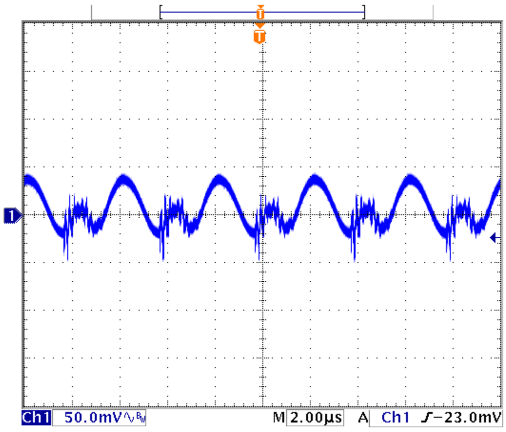
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



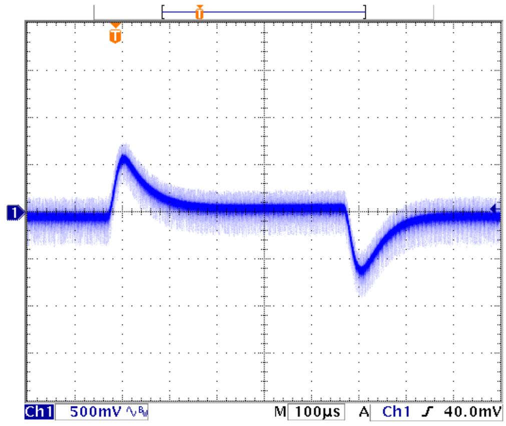
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

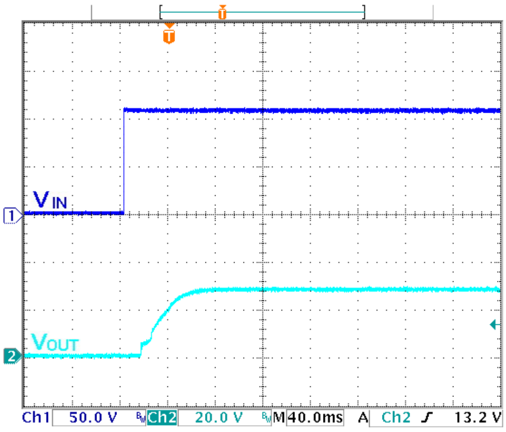
All test conditions are at 25°C. The figures are identical for TEP 160-7216WIR (continued)



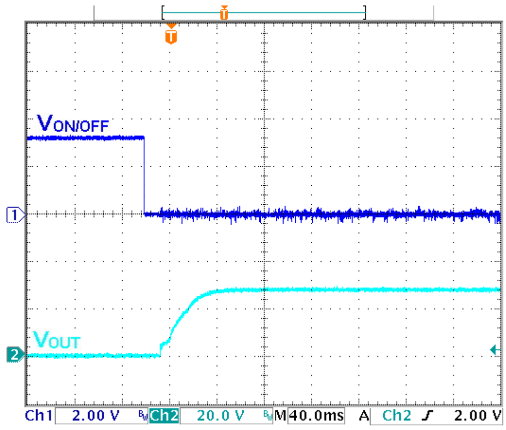
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



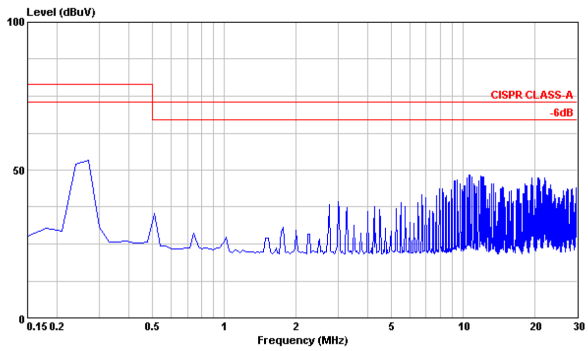
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



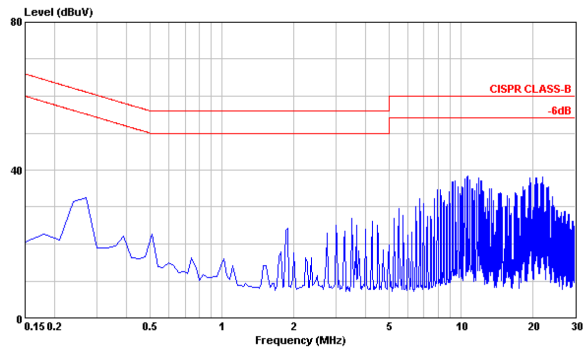
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



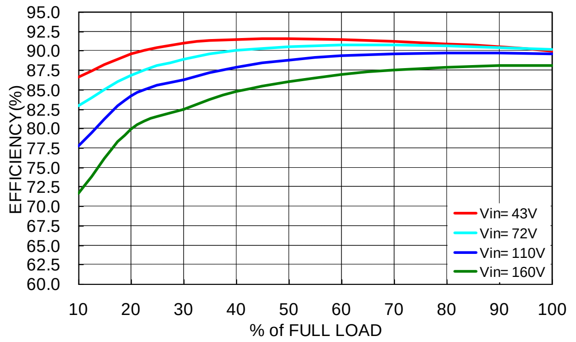
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



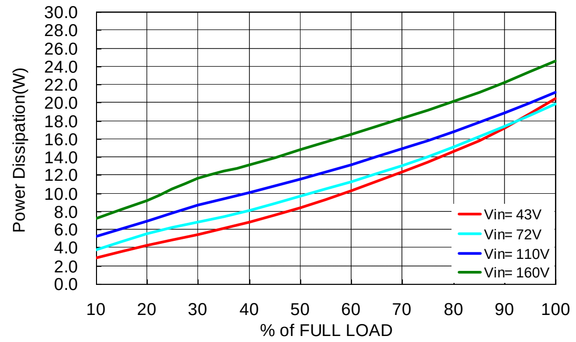
Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Characteristic Curves

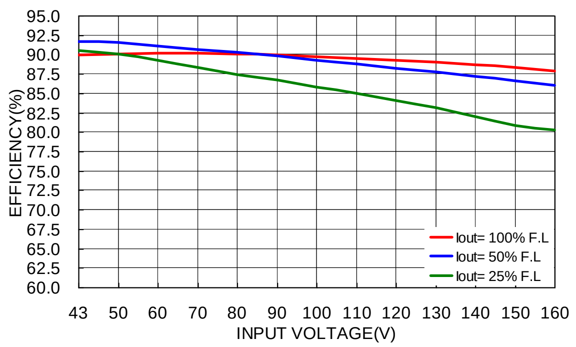
All test conditions are at 25°C. The figures are identical for TEP 160-7218WIR



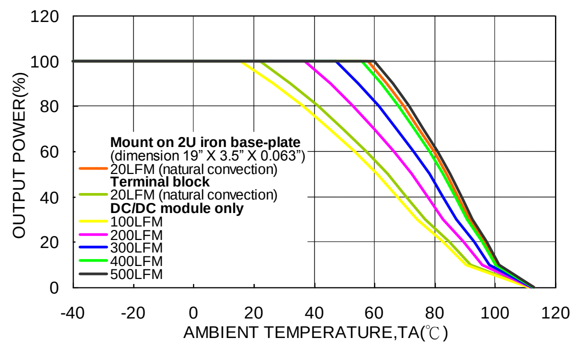
Efficiency versus Output Current



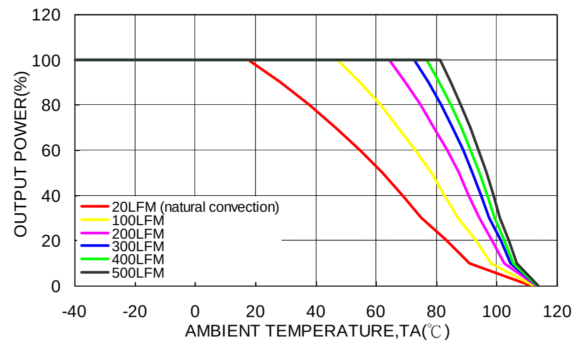
Power Dissipation versus Output Current



Efficiency versus Input Voltage. Full Load



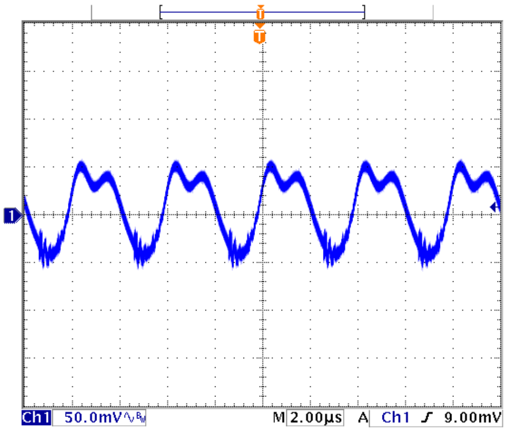
Derating Output Current versus Ambient Temperature with Airflow, $V_{in} = V_{in\ nom}$



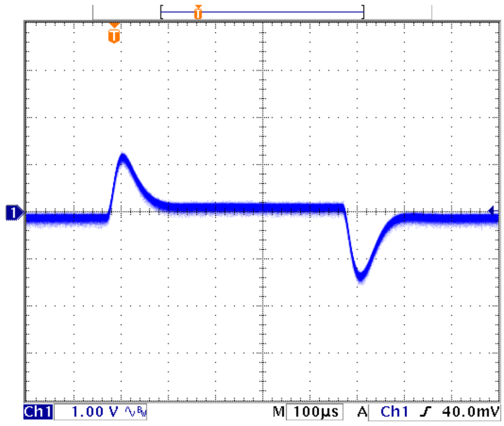
Derating Output Current Versus Ambient Temperature with Heat-Sink and Airflow, $V_{in} = V_{in\ nom}$

Characteristic Curves

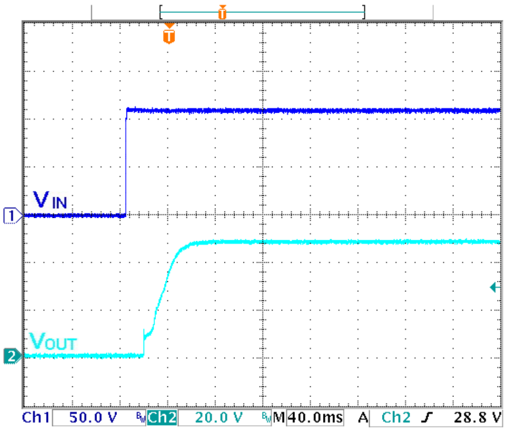
All test conditions are at 25°C. The figures are identical for TEP 160-7218WIR (continued)



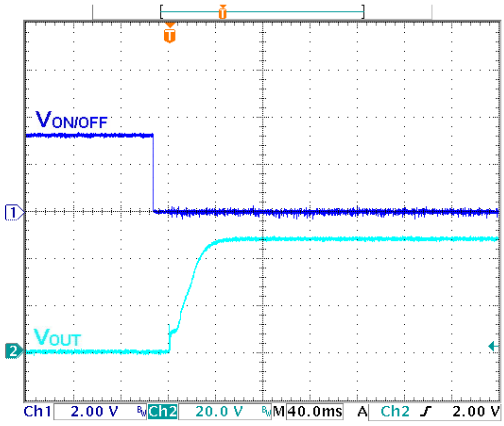
Typical Output Ripple and Noise.
$V_{in} = V_{in\ nom}$, Full Load



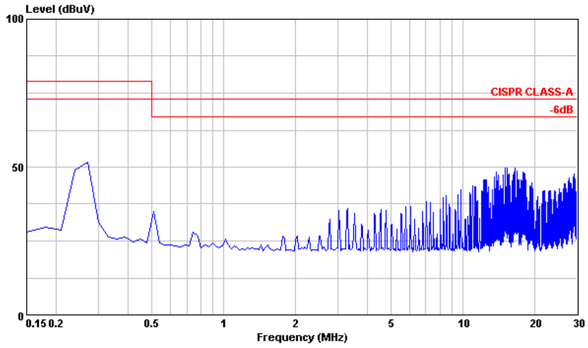
Transient Response to Dynamic Load Change from 100% to 75% to 100% of Full Load; $V_{in} = V_{in\ nom}$



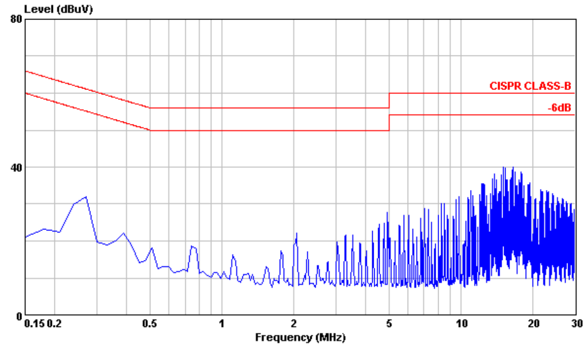
Typical Input Start-Up and Output Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



Using ON/OFF Voltage Start-Up and V_{out} Rise Characteristic
$V_{in} = V_{in\ nom}$, Full Load



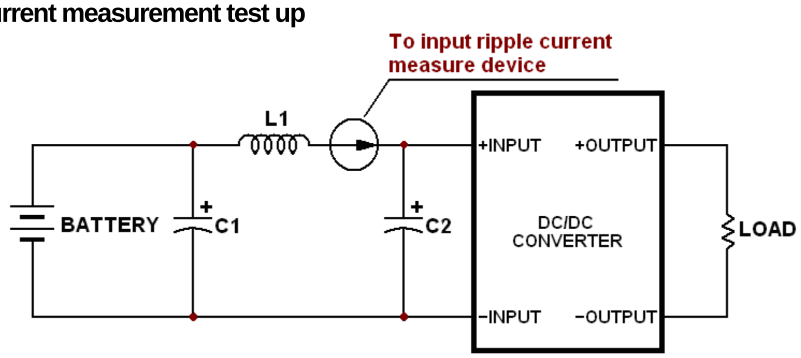
Conduction Emission of EN55022 Class A
$V_{in} = V_{in\ nom}$, Full Load



Conduction Emission of EN55022 Class B
$V_{in} = V_{in\ nom}$, Full Load

Testing Configurations

Input reflected-ripple current measurement test up



TEP 160-24xxWIR

Component	Value	Voltage	Reference
L1	12µH	----	
C1 & C2	330µF	50V	NIPPON CHEMI-CON : KY series

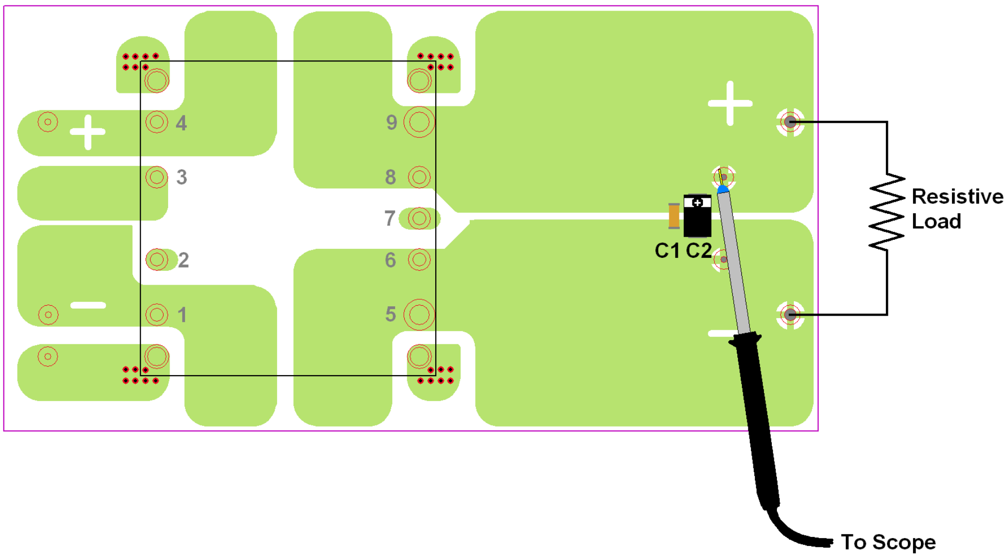
TEP 160-48xxWIR

Component	Value	Voltage	Reference
L1	12µH	----	
C1 & C2	220µF	100V	NIPPON CHEMI-CON : KY series

TEP 160-72xxWIR

Component	Value	Voltage	Reference
L1	12µH	----	
C1 & C2	68µF	200V	Ruby-con : BXF series

Peak to peak output ripple & noise measurement test up

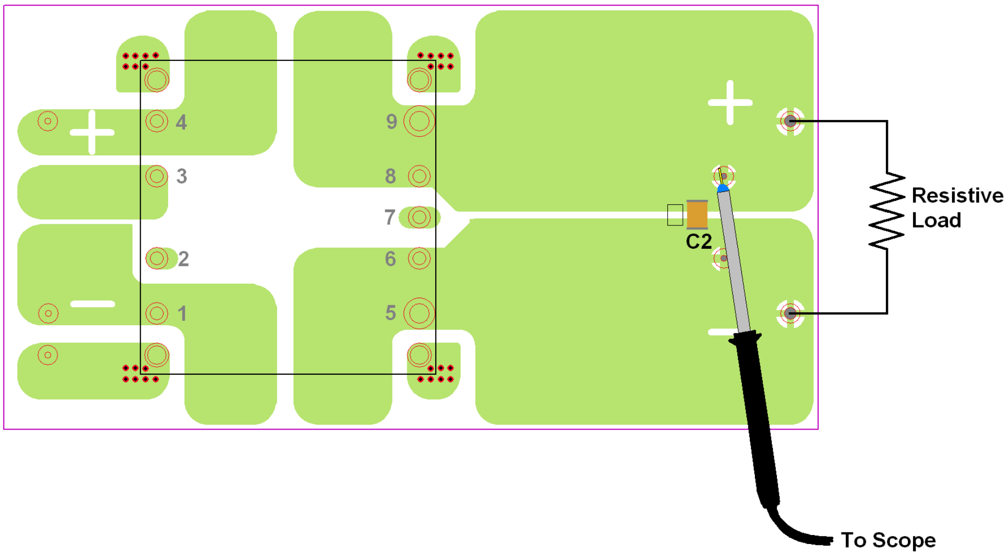


TEP 160-xx10WIR, TEP 160-xx11WIR, TEP 160-xx12WIR & TEP 160-xx13WIR

Component	Value	Voltage	Reference
C1	1µF	25V	TDK: C3216X7R1E105
C2	22µF	25V	SANYO: 25TQC22MV

Testing Configurations

Peak to peak output ripple & noise measurement test up



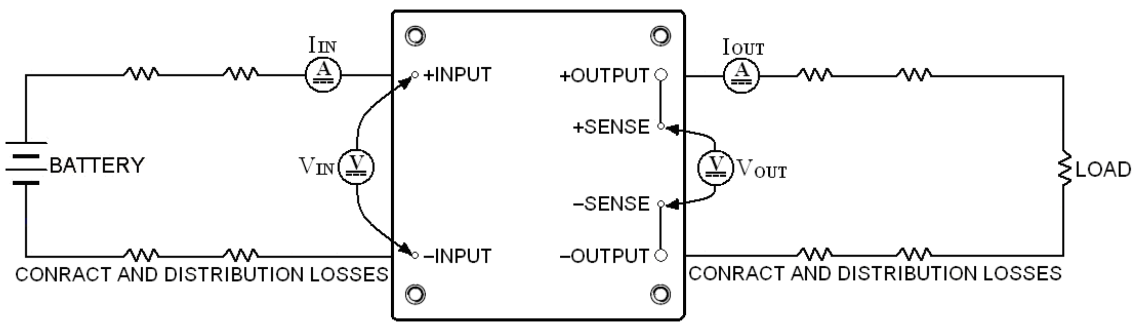
TEP 160-xx15WIR & TEP 160-xx16WIR

Component	Value	Voltage	Reference
C2	4.7µF	50V	TDK: C4532X7R1H475M

TEP 160-xx18WIR

Component	Value	Voltage	Reference
C2	2.2µF	100V	TDK: C4532X7R2A225M

Output voltage and efficiency measurement test up

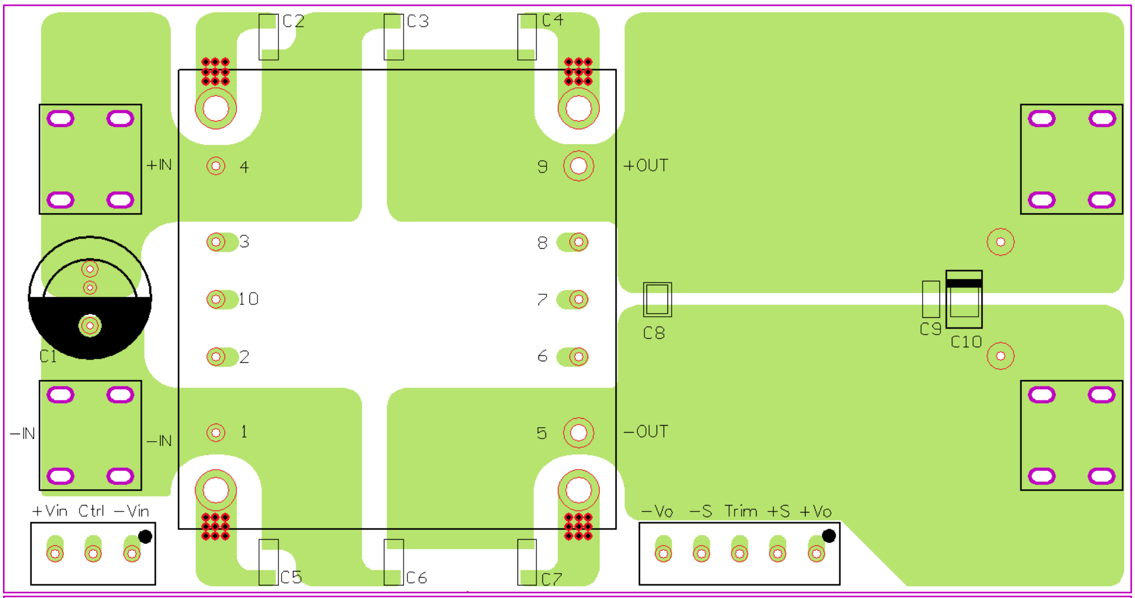


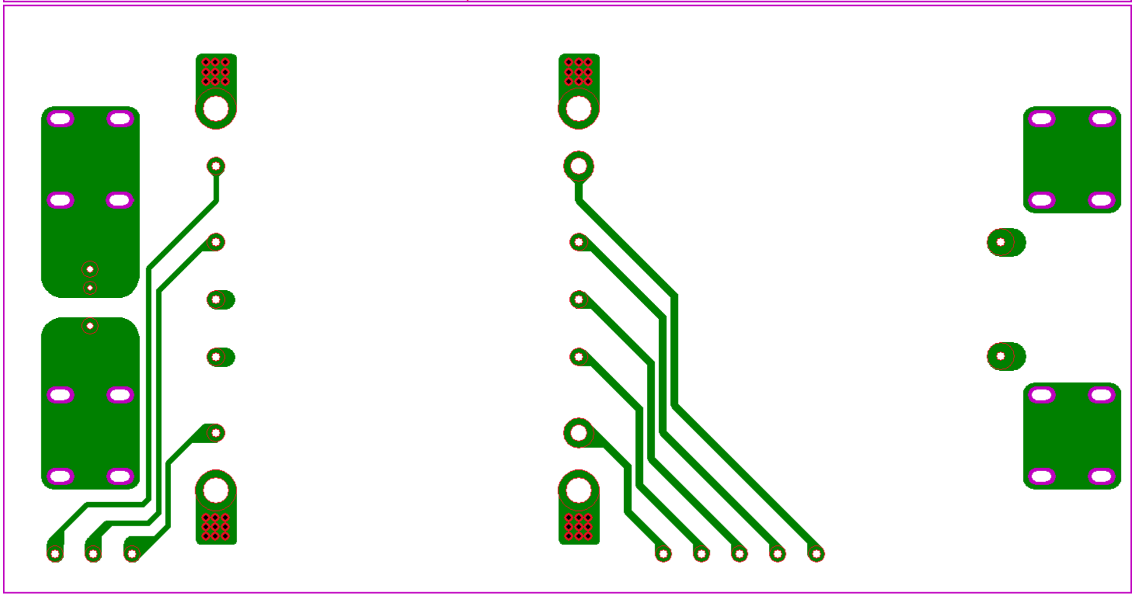
Note: All measurements are taken at the module terminals.

$$Efficiency = \left(\frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}} \right) \times 100\%$$

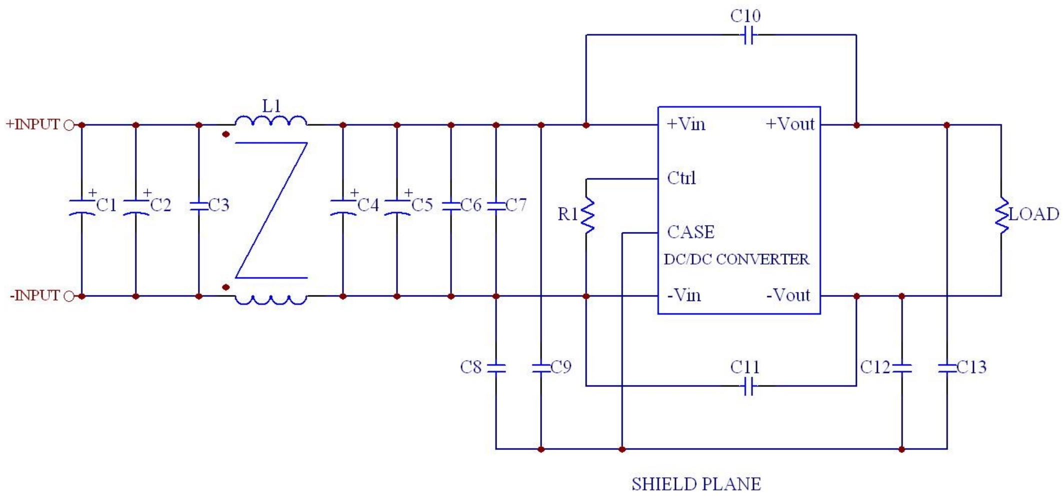
Testing Configurations

Output voltage and efficiency measurement test up

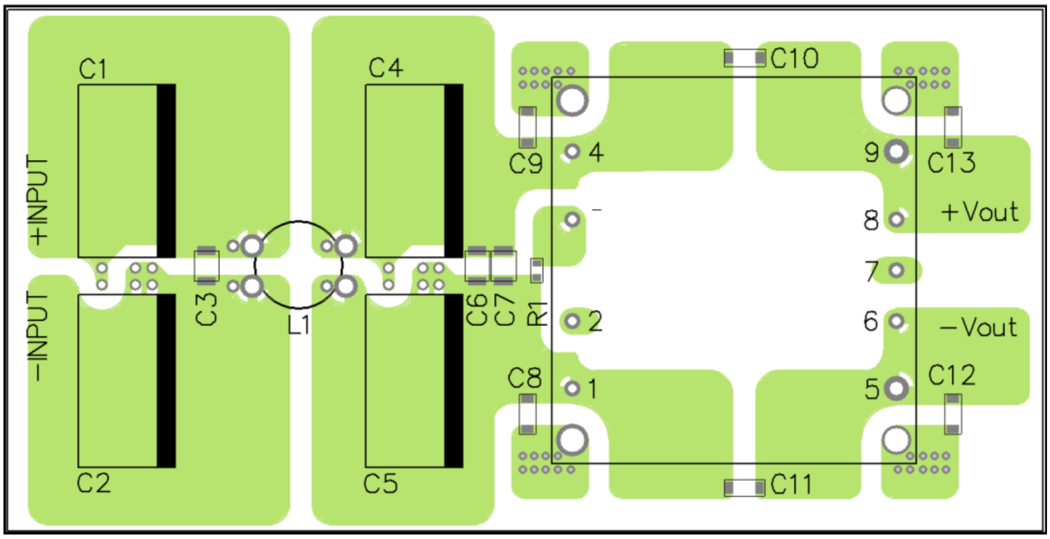




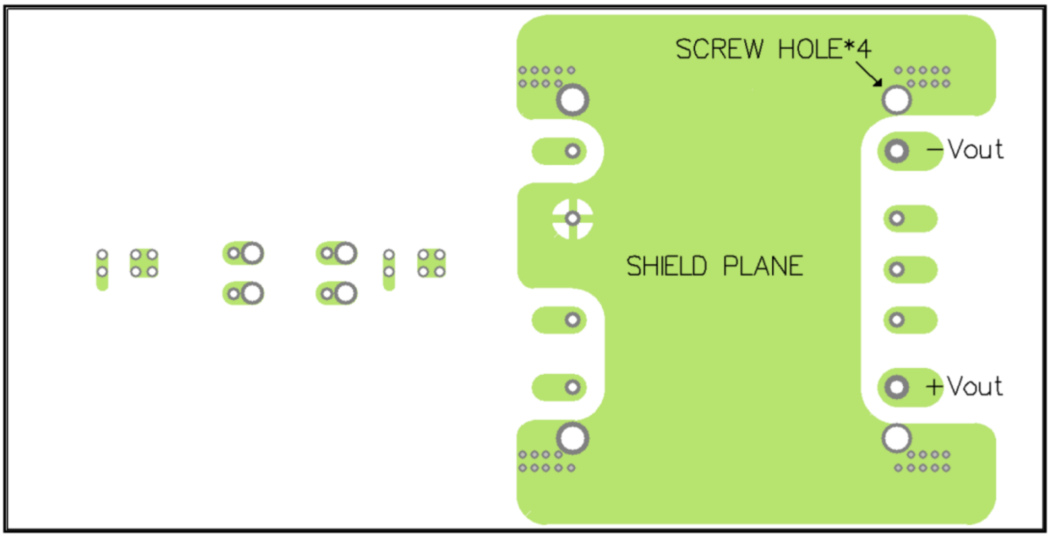
EMI considerations



Suggested schematic for EN55011,EN55022 conducted emission Class A limits



Recommended Layout With Input Filter



EMI considerations

To meet conducted emissions EN55011, EN55022 CLASS A needed the following components:

TEP 160-24xxWIR

Component	Value	Voltage	Reference
C1, C2, C4	470µF	50 V	Nippon Chemi-Con KY series
C3, C6, C7	4.7µF	50 V	1812 MLCC
C8, C9, C10, C11, C13	1000pF	3 kV	1808 MLCC
C12	3300pF	3 kV	1808 MLCC
L1	156µH ±35%	---	Common Choke, P/N: TCK-086

TEP 160-48xxWIR

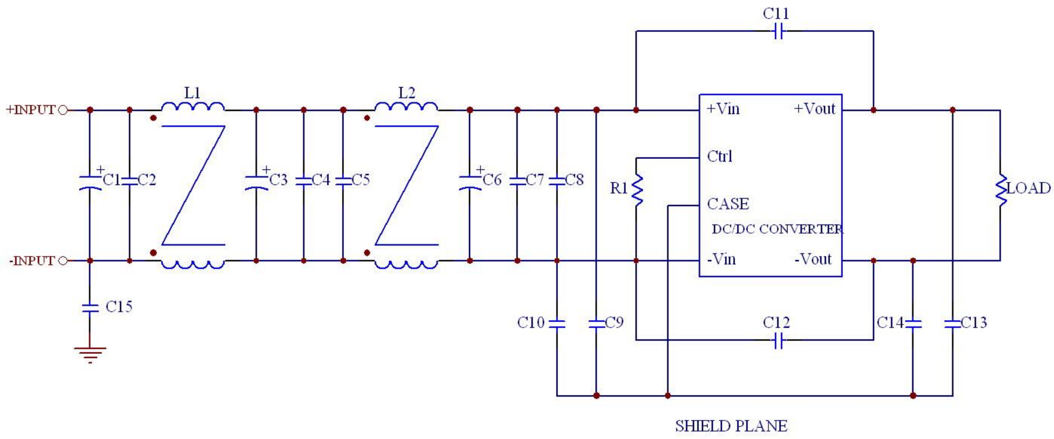
Component	Value	Voltage	Reference
C1, C2, C4	220µF	100 V	Nippon Chemi-Con KY series
C3, C6, C7	2.2µF	100 V	1812 MLCC
C8, C9, C10, C11, C13, C12	1000pF	3 kV	1808 MLCC
L1	224µH ±35%	---	Common Choke, P/N: TCK-087

TEP 160-72xxWIR

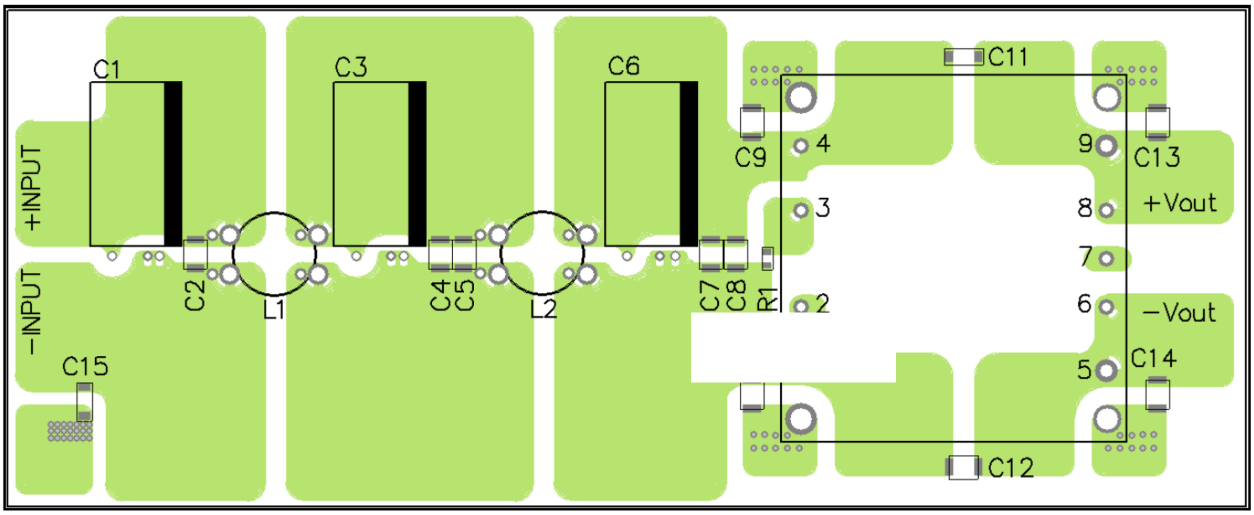
Component	Value	Voltage	Reference
C1, C2, C4	150uF	200V	Chemi-Con KYX series
C3, C6, C7	1µF	250 V	1812 MLCC
C8, C9, C10, C11, C13, C12	1000pF	3 kV	1808 MLCC
L1	521µH ±35%	----	Common Choke, P/N: TCK-088

Note: 1. Common mode choke have been define and show in page 56.
2. While testing, connect four screw bolts to shield plane, the EMI could be reduced.

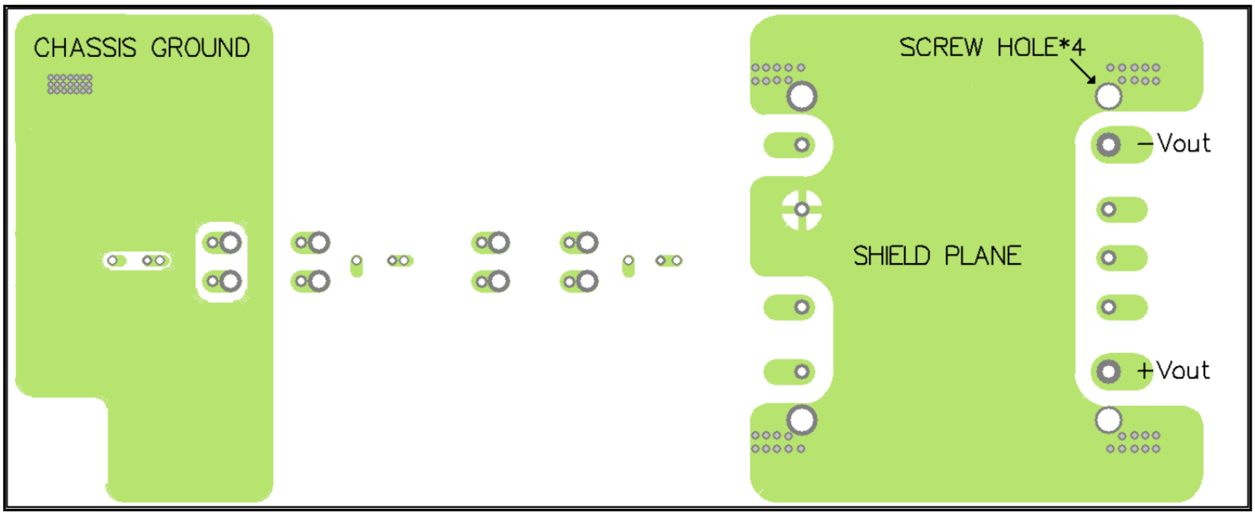
EMI considerations



Suggested schematic for EN55011,EN55022 conducted emission Class B limits



Recommended Layout With Input Filter



EMI considerations

To meet conducted emissions EN55011, EN55022 CLASS B needed the following components:

TEP 160-24xxWIR

Component	Value	Voltage	Reference
C1, C3, C6	470µF	50 V	Nippon Chemi-Con KY series
C2, C4, C5, C7, C8	4.7µF	50 V	1812 MLCC
C9, C10, C13, C14	10nF	2 kV	1812 MLCC
C11	1000pF	3 kV	1808 MLCC
C12	4700pF	3 kV	1812 MLCC
L1, L2	156µH ±35%	----	Common Choke, P/N: TCK-086

TEP 160-48xxWIR

Component	Value	Voltage	Reference
C1, C3, C6	220µF	100 V	Nippon Chemi-Con KY series
C2, C4, C5, C7, C8	2.2µF	100 V	1812 MLCC
C9, C10, C13, C14	10nF	2 kV	1812 MLCC
C11	2200pF	3 kV	1808 MLCC
C12	4700pF	3 kV	1812 MLCC
C15	1000pF	3 kV	1808 MLCC
L1, L2	224µH ±35%	----	Common Choke, P/N: TCK-087

TEP 160-72xxWIR

Component	Value	Voltage	Reference
C1, C3, C6	150µF	200 V	Rubycon BXF series
C2, C4, C5, C7, C8	1µF	250 V	1812 MLCC
C9, C10	2200pF	3 kV	1808 MLCC
C13, C14, C15	1000pF	3 kV	1808 MLCC
C11, C12	2200pF	3 kV	1808 MLCC
L1, L2	521µH ±35%	----	Common Choke, P/N: TCK-088

Note: 1. Common mode choke have been define and show in page 56.
2. While testing, connect four screw bolts to shield plane, the EMI could be reduced.

EMI considerations

These common mode choke have been define as follow：

■ **TCK-086** Inductance: 156μH±35%
Impedance: 2.5mΩ, max
Rated current: 21A, max.

■ **TCK-087** Inductance: 224μH±35%
Impedance: 3.6mΩ, max
Rated current: 15.4A, max.

■ **TCK-088** Inductance: 521μH±35%
Impedance: 12mΩ, max
Rated current: 7.7A, max

TBD
All dimensions in millimeters

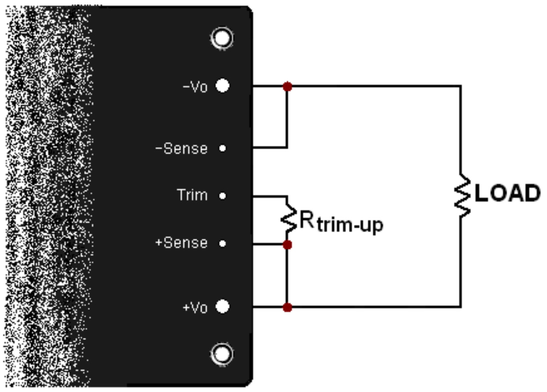
Measurement Instrument (Test condition):

■ L: HP 4263B LCR Meter (100KHz / 100mV)
■ DCR: HIOKI 3540mΩ HITESTER
■ IDC: Agilent 34401A Meter

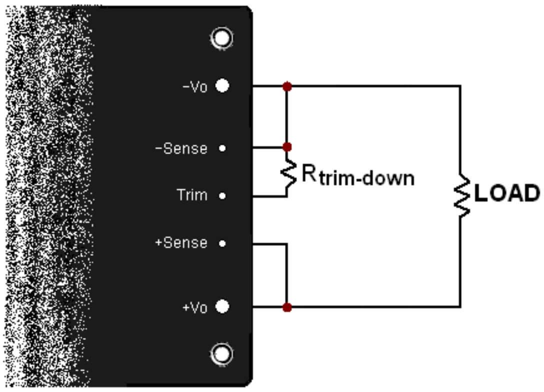
Recommended through hole: Φ1.0mm

Output Voltage Adjustment

Output voltage is adjustable for 10% trim up or -20% trim down of nominal output voltage by connecting an external resistor between the TRIM pin and either the +SENSE or -SENSE pins. With an external resistor between the TRIM and -SENSE pin, the output voltage set point decreases. With an external resistor between the TRIM and +SENSE pin, the output voltage set point increases. Maximum output deviation is +10% inclusive of remote sense. (Please refer to page 58, remote sense). The value of external resistor can be obtained by equation or trim table shown in next page. The external TRIM resistor needs to be at least 1/8W resistors.



TRIM UP



TRIM DOWN

Output Voltage Adjustment

TRIM EQUATION

$$R_U = \left(\frac{V_{OUT}\,(100+\Delta\%)}{1.225\Delta\%} - \frac{100+2\Delta\%}{\Delta\%} \right) K\Omega$$

$$R_D = \left(\frac{100}{\Delta\%} - 2 \right) K\Omega$$

TRIM TABLE

TEP 160-xx10WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	3.333	3.366	3.399	3.432	3.465	3.498	3.531	3.564	3.597	3.630
R_U (KΩ) =	170.082	85.388	57.156	43.041	34.571	28.925	24.892	21.867	19.515	17.633

TEP 160-xx11WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	5.05	5.10	5.15	5.20	5.25	5.30	5.35	5.40	5.45	5.50
R_U (KΩ) =	310.245	156.163	104.803	79.122	63.714	53.442	46.105	40.602	36.322	32.898

TEP 160-xx12WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	12.12	12.24	12.36	12.48	12.60	12.72	12.84	12.96	13.08	13.20
R_U (KΩ) =	887.388	447.592	300.993	227.694	183.714	154.395	133.452	117.745	105.528	95.755

TEP 160-xx13WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	15.15	15.30	15.45	15.60	15.75	15.90	16.05	16.20	16.35	16.50
R_U (KΩ) =	1134.735	572.490	385.075	291.367	235.143	197.660	170.886	150.806	135.188	122.694

TEP 160-xx15WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	24.24	24.48	24.72	24.96	25.20	25.44	25.68	25.92	26.16	26.40
R_U (KΩ) =	1876.776	947.184	637.320	482.388	389.429	327.456	283.190	249.990	224.168	203.510

TEP 160-xx16WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	28.28	28.56	28.84	29.12	29.40	29.68	29.96	30.24	30.52	30.80
R_U (KΩ) =	2206.571	1113.714	749.429	567.286	458.000	385.143	333.102	294.071	263.714	239.429

TEP 160-xx18WIR

Trim up (%)	1	2	3	4	5	6	7	8	9	10
V_{OUT} (Volts) =	48.48	48.96	49.44	49.92	50.40	50.88	51.36	51.84	52.32	52.80
R_U (KΩ) =	3855.551	1946.367	1309.973	991.776	800.857	673.578	582.665	514.480	461.447	419.020

All TEP 160-xxxxWIR

Trim down (%)	1	2	3	4	5	6	7	8	9	10
R_D (KΩ) =	98.000	48.000	31.333	23.000	18.000	14.667	12.286	10.500	9.111	8.000
Trim down (%)	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
R_D (KΩ) =	7.091	6.333	5.692	5.143	4.667	4.250	3.882	3.556	3.263	3.000

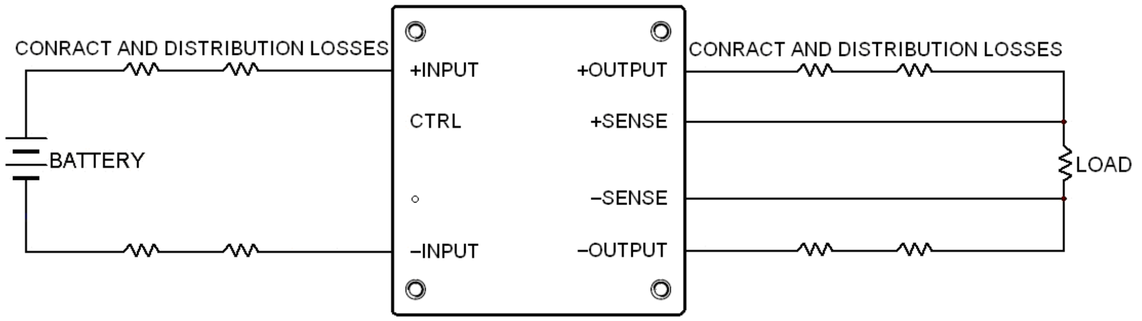
Remote Sense

To minimize the effects of distribution losses by regulating the voltage at the Remote Sense pin. The voltage between the SENSE pin and OUTPUT pin must not exceed 10% of Vout, i.e.

[+OUTPUT to –OUTPUT] – [+SENSE to –SENSE] < 10% Vout

The voltage between +OUTPUT and –OUTPUT terminals must not exceed the minimum output overvoltage protection threshold. This limit includes any increase in voltage due to remote sense compensation and trim function.

If not using the remote sense feature to regulate the output at the point of load, then connect +SENSE to +OUTPUT and –SENSE to –OUTPUT.



Remote Sense circuit configuration

Input Source Impedance

The power modules will operate as specifications without external components, assuming that the source voltage has a very low impedance and reasonable input voltage regulation. Highly inductive source impedances can affect the stability of the power module. Since real-world voltage source has finite impedance, performance can be improved by adding external filter capacitor

The TEP 160-24xxWIR and TEP 160-48xxWIR recommended Nippon Chemi-Con KY series, 100µF/100V, ESR 110mΩ.
The TEP 160-72xxWIR recommended Ruby-con BXF series, 68µF/200V.

Output Over Current Protection

When excessive output currents occur in the system, circuit protection is required on all power supplies. Normally, overload current is maintained at approximately 120~150 percent of rated current for TEP 160WIR series.

Hiccup-mode is a method of operation in a power supply whose purpose is to protect the power supply from being damaged during an over-current fault condition. It also enables the power supply to restart when the fault is removed. There are other ways of protecting the power supply when it is over-loaded, such as the maximum current limiting or current foldback methods.

One of the problems resulting from over current is that excessive heat may be generated in power devices, especially MOSFET and Schottky diodes and the temperature of those devices may exceed their specified limits. A protection mechanism has to be used to prevent those power devices from being damaged.

The operation of hiccup is as follows. When the current sense circuit sees an over-current event, the controller shuts off the power supply for a given time and then tries to start up the power supply again. If the over-load condition has been removed, the power supply will start up and operate normally, otherwise, the controller will see another over-current event and shut off the power supply again, repeating the previous cycle. Hiccup operation has none of the drawbacks of the other two protection methods, although its circuit is more complicated because it requires a timing circuit. The excess heat due to overload lasts for only a short duration in the hiccup cycle, hence the junction temperature of the power devices is much lower.

The hiccup operation can be done in various ways. For example, one can start hiccup operation any time an over-current event is detected, or prohibit hiccup during a designated start-up is usually larger than during normal operation and it is easier for an over-current event is detected, or prohibit hiccup during a designated start-up interval (usually a few milliseconds). The reason for the latter operation is that during start-up, the power supply needs to provide extra current to charge up the output capacitor. Thus the current demand during start-up is usually larger than during normal operation and it is easier for an over-current event to occur. If the power supply starts to hiccup once there is an over-current, it might never start up successfully. Hiccup mode protection will give the best protection for a power supply against over current situations, since it will limit the average current to the load at a low level, so reducing power dissipation and case temperature in the power devices.

Short Circuitry Protection

Continuous, hiccup and auto-recovery mode.
During short circuit, converter still shut down. The average current during this condition will be very low and the device can be safety in this condition.

Output Over Voltage Protection

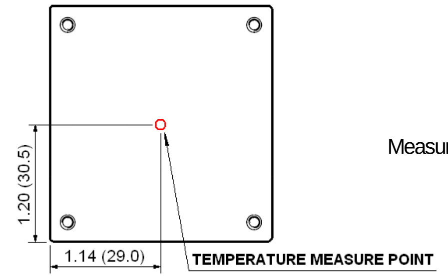
The output over-voltage protection consists of circuitry that monitors the voltage on the output terminals. If the voltage on the output terminals exceeds the over-voltage protection threshold, then the module enter the non-latch hiccup mode.

Over Temperature Protection

Sufficient cooling is needed for the power module and provides more reliable operation of the unit. If a fault condition occurs, the temperature of the unit will be higher. And will damage the unit. For protecting the power module, the unit includes over-temperature protection circuit. When the temperature of the case is to the protection threshold, the unit enters "Hiccup" mode. And it will auto restart when the temperature is down.

Thermal Consideration

TEP 160WIR is a high power density product, it operates in a variety of thermal environments. However, sufficient cooling should be provided to ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment.
Proper cooling can be verified by measuring the point as the figure below. The case temperature at this location is -40 ~115°C. When operating, although the maximum point temperature of the power modules is 115°C, we suggest to keep the test point temperature at or below 80°C for extremely high reliability, so the module can be in stable operation and get better lifecycle.



Measurement shown in inches (mm)

TOP VIEW

The suggested heat dissipation modes as below:

1. Add the heat-sink

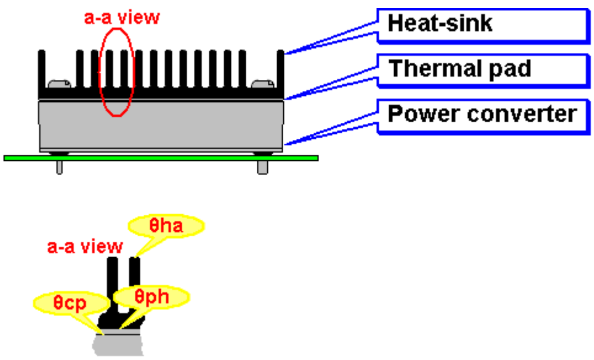
The main function of heat-sink is to add the touch surface of heat source for air. Under the suitable air convection condition (including natural convection), that can reduce the heat resistance θca apparently.

After combination of the heat resistance θca, it's the sub-total of θcp, θph and θha. Because the air gets big heat resistance under no air convection, the θha which touch the air is the main heat resistance.

Suggestions as below:

(1) θca = θcp + θph + θha. In order to let the heat-sink reducing the θha in big range, we suggest to use the thermal pad with good heat conduction and flushing performance.

(2) The best layout for heat sink is to put the fin of the heat-sink vertical to the air, and this will cause a good "stack effect". So, we can have the best natural air convection condition. When there's no force air to help the heat dissipation, this point is critical.

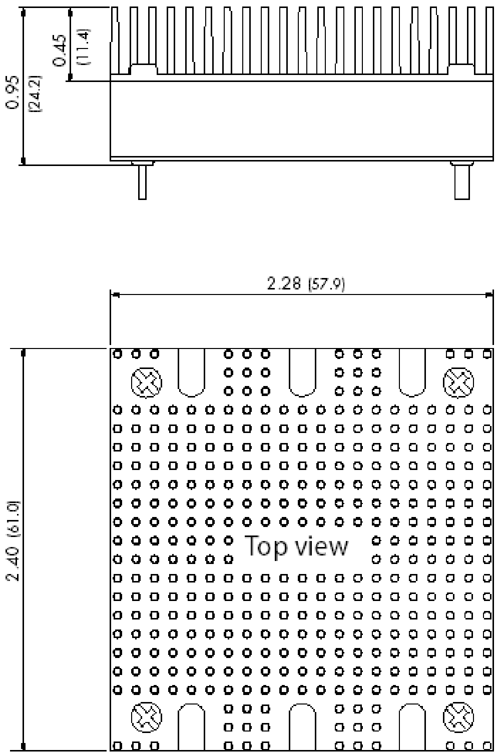


2. Force Air

Normally, we use the fan for the force air. By the air movement rapidly, it can bring the heat energy from the case surface. This is a good solution to reduce the heat resistance θca of the module. When the air speed is bigger, the heat resistance is smaller, and the heat dissipation performance is better.

Heat Sink

Heat-sink for lower temperature and higher reliability of the module. Order Code: TEP-HS1

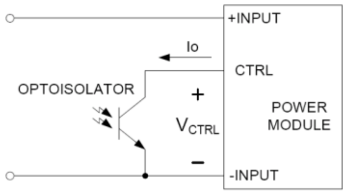


Order code: TEP-HS1
Includes heatsink with thermal pad and mounting screws.
To order modules with mounted heatsink, please ask factory.

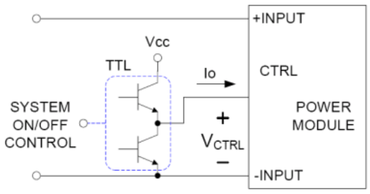
Remote ON/OFF Control

The CTRL Pin is controlled DC/DC power module to turn on and off, the user must use a switch to control the logic voltage high or low level of the pin referenced to -INPUT. The switch can be open collector transistor, FET and Photo-Couple. The switch must be capable of sinking up to 1 mA at low-level logic voltage. High-level logic of the CTRL pin signal maximum voltage is allowable leakage current of the switch at 12V is 0.5 mA.

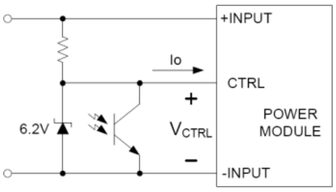
Remote ON/OFF Implementation Circuits



Isolated-Closure Remote ON/OFF



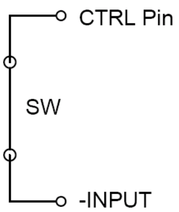
Level Control Using TTL Output



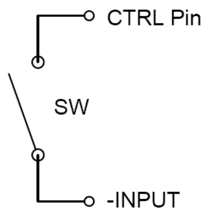
Level Control Using Line Voltage

There are two remote control options available, positive logic and negative logic.

a. The Positive logic structure turned on of the DC/DC module when the CTRL pin is at high-level logic and low-level logic is turned off it.

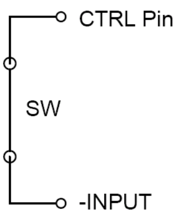


When TEP 160-xxxxWIR module is turned off at Low-level logic

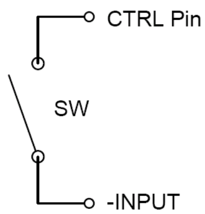


When TEP 160-xxxxWIR module is turned on at High-level logic

b. The Negative logic structure turned on of the DC/DC module when the CTRL pin is at low-level logic and turned off when at high-level logic.



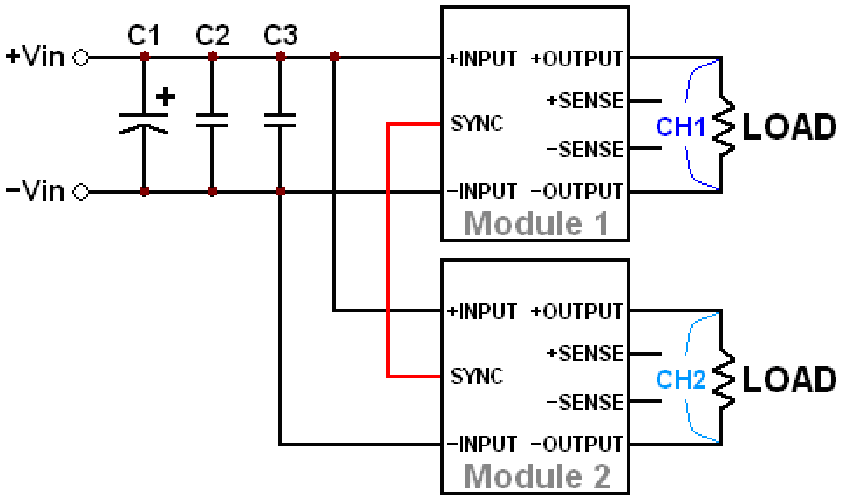
When TEP 160-xxxxWIR module is turned on at Low-level logic



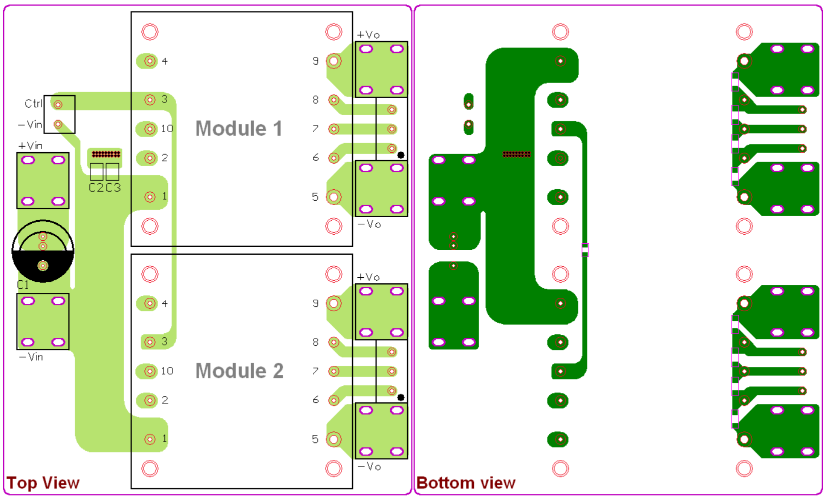
When TEP 160-xxxxWIR module is turned off at High-level logic

Synchronous Pin (optional)

1. Multiple TEP 160-xxxxWIR series module can be synchronized together simply by connecting the module SYNC pins together.



Synchronous Circuits



Recommended Layout

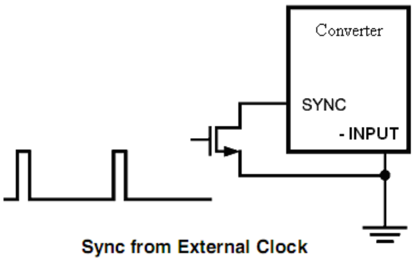
NOTE:

(1) Care should be taken to ensure the ground potential differences between modules are minimized.
(2) In this configuration all of the modules will be synchronized to the highest frequency module.
(3) Up to three modules can be synchronized using this technique.

2. The SYNC pin can be used to synchronize the internal oscillator to an external clock.

NOTE:

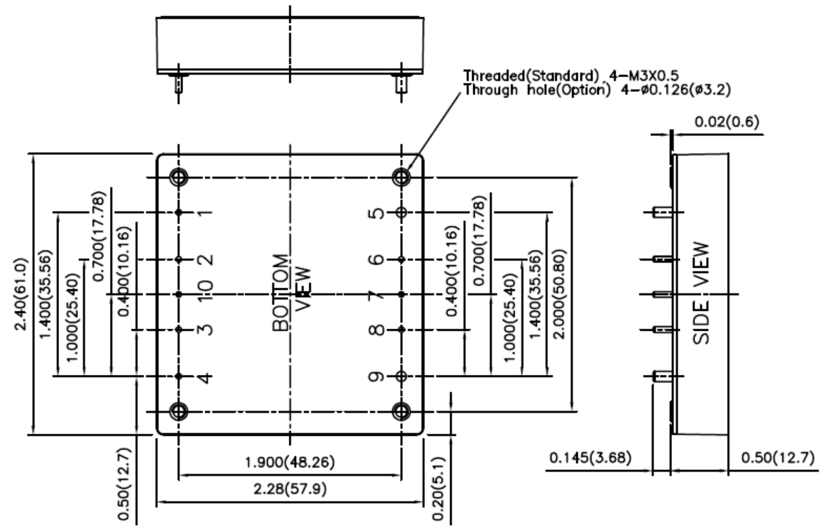
(1) The internal oscillator can be synchronized to an external clock with an external pull-down device. An open drain output is the recommended interface between the external clock to the SYNC pin.
(2) The clock pulse width must be greater than 15 ns.
(3) The external clock frequency must be a higher than the converter frequency. (Max. frequency < 280kHz)
(4) Sync Threshold (falling) voltage is 1.4V typical.
(5) Care should be taken to ensure the ground potential differences between modules are minimized.



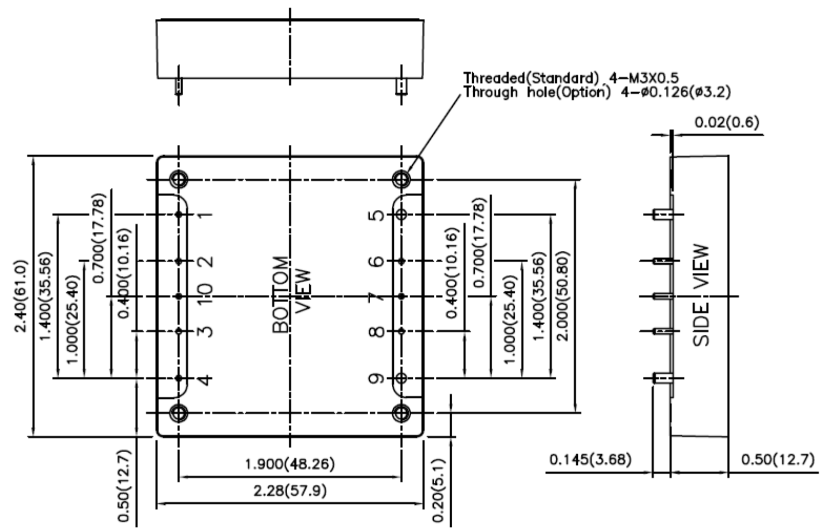
Sync from External Clock

Mechanical Data Of The Standard Product

Metal Case Mechanical Drawing



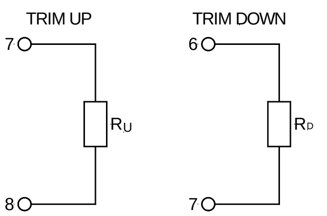
Plastic Case Mechanical Drawing



1. All dimensions in inch (mm)
2. Tolerance: x.xx ±0.02 (x.x ±0.5)
   x.xxx ±0.01 (x.xx ±0.25)
3. Pin pitch tolerance: ±0.01 (0.25)
4. Pin dimension tolerance: ±0.004(0.1)

EXTERNAL OUTPUT TRIMMING

Output can be externally trimmed by using the method shown below.

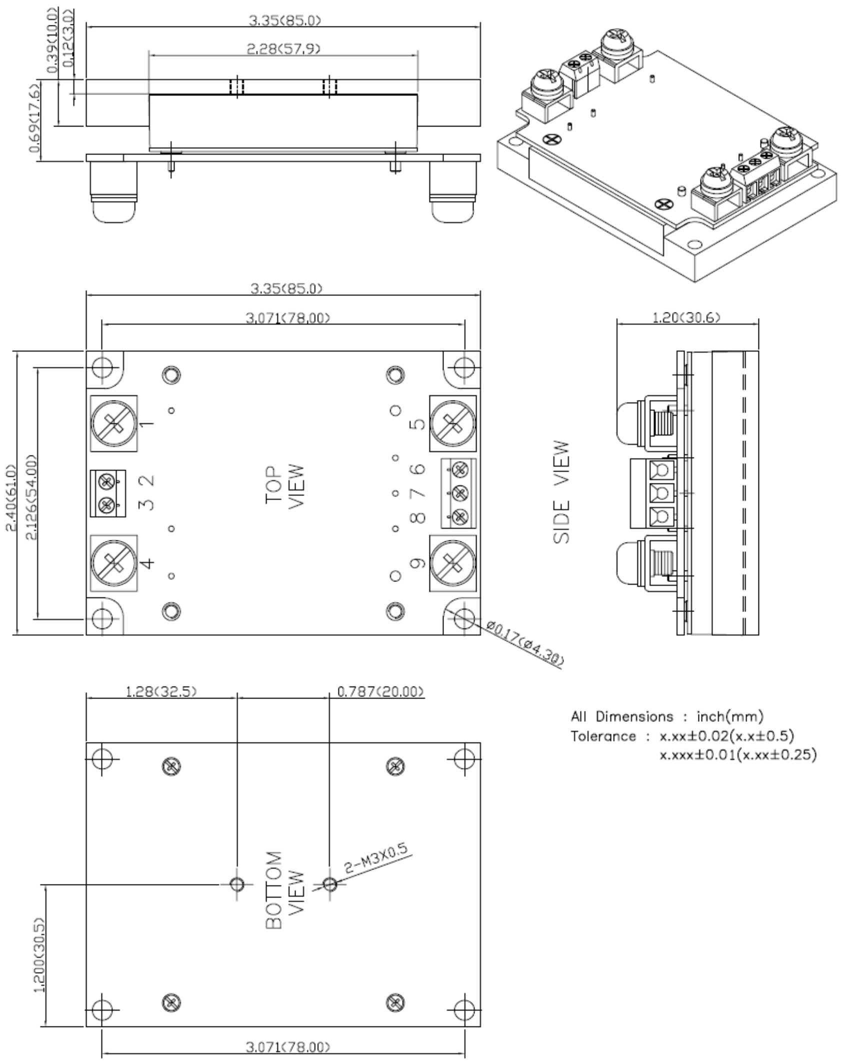


TERMINAL CONNECTION

Pin	Define	Diameter
1	- INPUT	0.04 inch
2	CASE	0.04 inch
3	CTRL	0.04 inch
4	+ INPUT	0.04 inch
5	- OUTPUT	0.08 inch
6	- SENSE	0.04 inch
7	TRIM	0.04 inch
8	+ SENSE	0.04 inch
9	+ OUTPUT	0.08 inch
10	SYNC (Option)	0.04 inch

Mechanical Data Of The Terminal Block Type

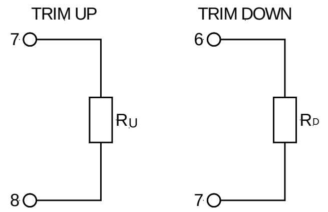
1. Terminal Block without EMC Filter, Suffix: -CM



Note: These two M3×0.5 threaded holes are designed for Din Rail Clip assembly. The depth of heat-sink is allowed to be screwed into 2.8mm maximum. Customer shall take care as select the screw to avoid damaging the converter.

EXTERNAL OUTPUT TRIMMING

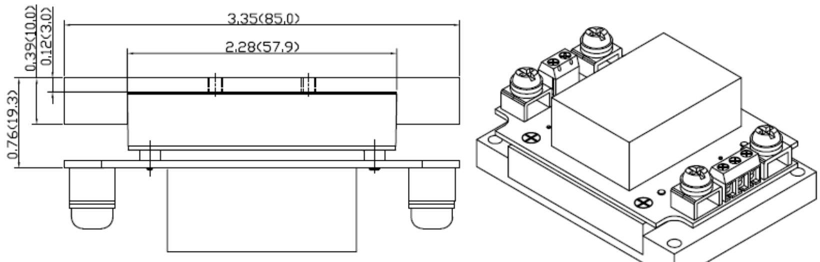
Output can be externally trimmed by using the method shown below.

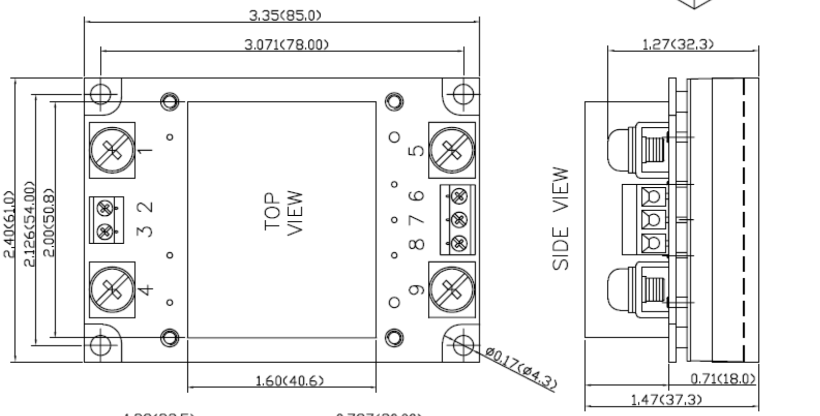


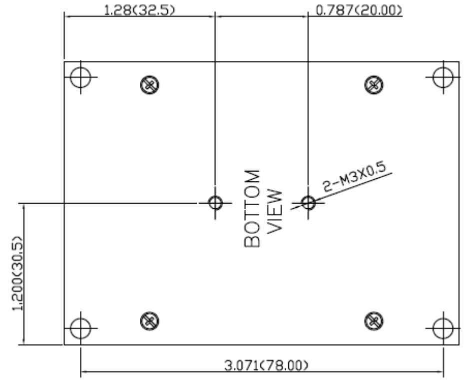
TERMINAL CONNECTION		
Pin	Define	Wire Range
1	- INPUT	8AWG to 9AWG
2	CASE	14AWG to 18AWG
3	CTRL	14AWG to 18AWG
4	+ INPUT	8AWG to 9AWG
5	- OUTPUT	4AWG to 5AWG
6	- SENSE	14AWG to 18AWG
7	TRIM	14AWG to 18AWG
8	+ SENSE	14AWG to 18AWG
9	+ OUTPUT	4AWG to 5AWG

Mechanical Data Of The Terminal Block Type

2. Terminal Block with EMC Filter (EN55011, EN55022 Class A), Suffix: -CMF





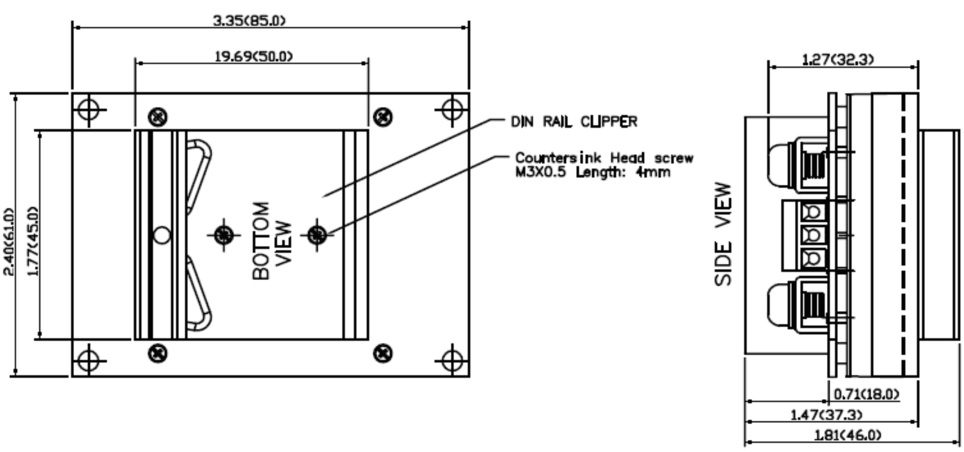


All Dimensions : inch(mm)
Tolerance : x.xx±0.02(x.x±0.5)
x.xxx±0.01(x.xx±0.25)

Terminal Connection see above!

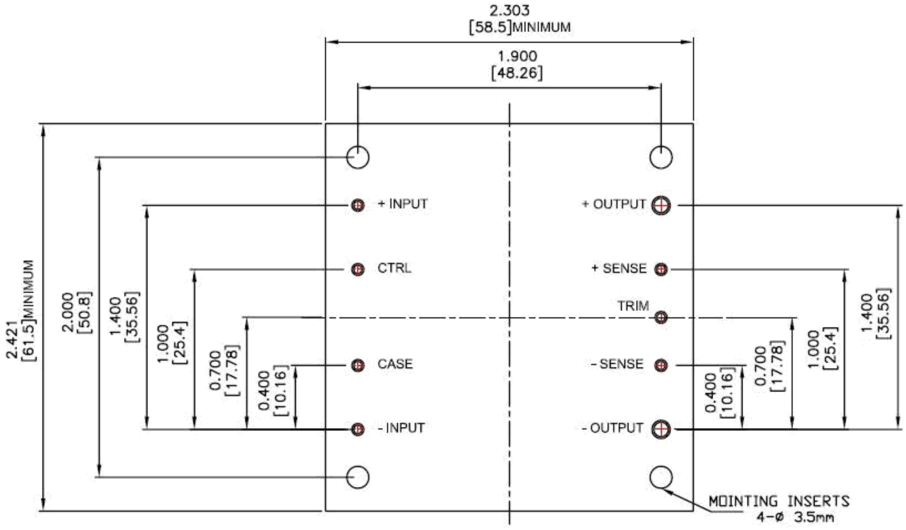
Note: These two M3×0.5 threaded holes are designed for Din Rail Clip assembly. The depth of heat-sink is allowed to be screwed into 2.8mm maximum.

3. Terminal Block with Din Rail Clip TEP-MK1 (DIN-Rail incl. screws)



Recommended Pad Layout

All dimensions in inch (mm)
Tolerances : x.xxx ± 0.010 (x.xx ± 0.25)



PAD SIZE (LEAD FREE RECOMMENDED)

± OUTPUT:

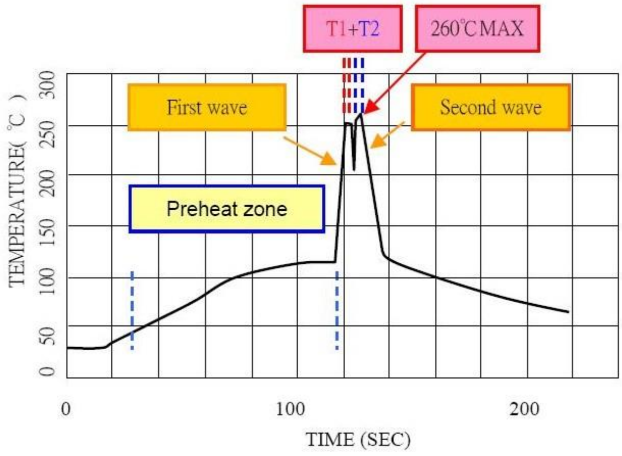
THROUGH HOLE:	Ø 2.3mm
TOP VIEW PAD:	Ø 2.9mm
BOTTOM VIEW PAD:	Ø 3.6mm

OTHERS:

THROUGH HOLE:	Ø 1.3mm
TOP VIEW PAD:	Ø 1.9mm
BOTTOM VIEW PAD:	Ø 2.6mm

Soldering Considerations

Lead free wave solder profile for TEP 160WIR series



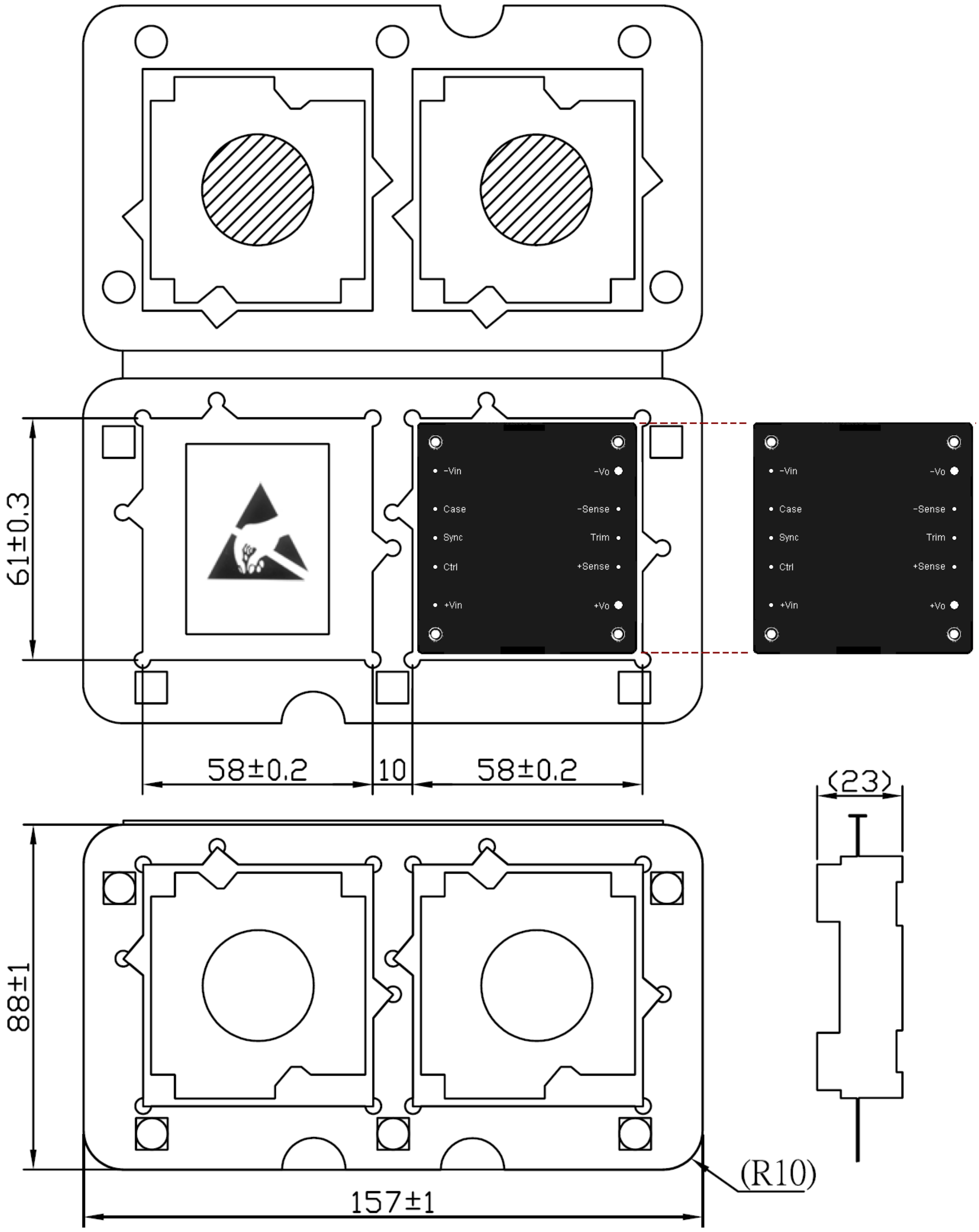
Zone	Reference Parameter
Preheat zone	Rise temp. speed: 3°C/sec max. Preheat temperature: 100~130°C
Actual heating	Peak temperature: 250~260°C Peak time (T1+T2 time): 4~6 sec

Reference Solder: Sn-Ag-Cu , Sn-Cu

Hand Welding:

Soldering iron: Power 90W
Welding Time: 2~4 sec
Temperature: 380~400°C

Packaging Information



Dimensions shown in millimeters

Part Number Structure

Model Number	Input Range	Output Voltage	Output Current Max. Load	Input Current No Load (1)	Efficiency (2) (%)
TEP 160-2410WIR	9 ~ 36 Vdc	3.3Vdc	40.0A	25mA	88
TEP 160-2411WIR	9 ~ 36 Vdc	5Vdc	28.0A	30mA	90
TEP 160-2412WIR	8.5 ~ 36 Vdc	12Vdc	12.0A	30mA	90
TEP 160-2413WIR	8.5 ~ 36 Vdc	15Vdc	9.5A	30mA	91
TEP 160-2415WIR	8.5 ~ 36 Vdc	24Vdc	6.0A	35mA	90
TEP 160-2416WIR	8.5 ~ 36 Vdc	28Vdc	5.0A	40mA	90
TEP 160-2418WIR	8.5 ~ 36 Vdc	48Vcd	3.0A	45mA	90
TEP 160-4810WIR	16.5 ~ 75 Vdc	3.3Vdc	40.0A	20mA	89
TEP 160-4811WIR	16.5 ~ 75 Vdc	5Vdc	30.0A	20mA	91
TEP 160-4812WIR	16.5 ~ 75 Vdc	12Vdc	13.0A	20mA	91
TEP 160-4813WIR	16.5 ~ 75 Vdc	15Vdc	10.0A	20mA	91
TEP 160-4815WIR	16.5 ~ 75 Vdc	24Vdc	6.5A	20mA	91
TEP 160-4816WIR	16.5 ~ 75 Vdc	28Vdc	5.5A	25mA	91
TEP 160-4818WIR	16.5 ~ 75 Vdc	48Vcd	3.2A	25mA	91
TEP 160-7210WIR	43 ~ 160 Vdc	3.3Vdc	43.0A	10mA	88
TEP 160-7211WIR	43 ~ 160 Vdc	5Vdc	32.0A	10mA	90
TEP 160-7212WIR	43 ~ 160 Vdc	12Vdc	15.0A	10mA	90
TEP 160-7213WIR	43 ~ 160 Vdc	15Vdc	12.0A	10mA	90
TEP 160-7215WIR	43 ~ 160 Vdc	24Vdc	7.5A	10mA	90
TEP 160-7216WIR	43 ~ 160 Vdc	28Vdc	6.5A	15mA	90
TEP 160-7218WIR	43 ~ 160 Vdc	48Vcd	3.8A	15mA	90

Note 1. Typical value at nominal input and no load.
Note 2. Typical value at nominal input and full load.

Safety and Installation Instruction

Fusing Consideration

Caution: This power module is not internally fused. An input line fuse must always be used.
This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of sophisticated power architecture. To maximum flexibility, internal fusing is not included, however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a fast blow fuse with maximum rating of 30A for TEP 160-24xxWIR, 15A for TEP 160-48xxWIR and 7A for TEP 160-72xxWIR. Based on the information provided in this data sheet on Inrush energy and maximum dc input current, the same type of fuse with lower rating can be used. Refer to the fuse manufacturer's data for further information.

MTBF and Reliability

The MTBF of TEP 160WIR series DC/DC converters has been calculated using

Bellcore TR-NWT-000332 Case I: 50% stress, Operating Temperature at 40°C (Ground fixed and controlled environment). The resulting figure for MTBF is 1'010'000 hours.

MIL-HDBK 217F NOTICE2 FULL LOAD, Operating Temperature at 25°C. The resulting figure for MTBF is 74'160 hours.