TEN 15 Series Power Modules

Application Note

DC/DC Converter 9 to 18Vdc, 18 to 36Vdc or 36 to 75 Vdc Input
3.3 to 15Vdc Single Outputs and ±5 to ±15Vdc Dual Outputs, 15W

E188913

Complete TEN 15 datasheet can be downloaded at:
http://www.tracopower.com/products/ten15.pdf

Features

- RoHS compliant
- Single output up to 2.4A
- Dual output up to ±800mA
- Low profile: 2.0 x 1.0 x 0.4 inches (50.8 x 25.4 x 10.2mm)
- 2：1 wide input voltage 9-18Vdc, 18-36Vdc and 36-75Vdc
- 15 Watts output power
- Input to output isolation: 1500Vdc for 1 minute
- Operating case temperature range: 100°C max
- Over-current protection, auto-recovery
- Output over voltage protection
- ISO 9001 certified manufacturing facilities
- UL60950-1 Recognised E188913
- Complies with EN 55022 class A conducted noise

Applications

- Distributed power architectures
- Communication equipment
- Computer equipment

General Description

The TEN 15-Modules Power Modules provide 15 watts of isolated, regulated output power, in a standard two by one inches module size, with wide input voltage ranges either 9 – 18Vdc, 18 – 36Vdc or 36 – 75Vdc. It is available with output voltages from 3.3Vdc up to 15Vdc (single output) or ±5Vdc up to ±15Vdc (dual output). The physical design of the unit employs a full five sides metallic case for heat dissipation, and encloses the circuitry in a six-sided shield.

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Absolute Maximum Rating					
Parameter	Device	Min	Typ	Max	Unit
Input Voltage Continuous Transient (100ms)	TEN 15-12xx			36	Vdc
	TEN 15-24xx			50	Vdc
	TEN 15-48xx			100	Vdc
Operating temperature range (With Derating curve)	Standard	-40		+85	°C
Operating case range	All			100	°C
Storage temperature	All	-55		+105	°C
I/O Isolation voltage (60 seconds)	All	1500			Vdc
I/O Isolation capacitance	All			300	pF

Output Specifications					
Parameter	Device	Min	Typ	Max	Unit
Operating Output Range	TEN 15-xx10	3.26	3.3	3.33	Vdc
	TEN 15-xx11	4.95	5.0	5.05	
	TEN 15-xx12	11.88	12.0	12.12	
	TEN 15-xx13	14.85	15.0	15.15	
	TEN 15-xx21	±4.95	±5.0	±5.05	
	TEN 15-xx22	±11.88	±12.0	±12.12	
	TEN 15-xx23	±14.85	±15.0	±15.15	
Line Regulation(LL to HL at Full Load)	All			0.5	%
Load Regulation(25% to 100% Full Load)	All			0.5	%
Output Ripple & Noise (20MHz bandwidth)	All			50	mV pk-pk
Temperature Coefficient	All	-0.02		+0.02	%/°C
Transient Response Recovery Time (25%/100% load step change)	All		250		µS
Output Current	TEN 15-xx10	400		4000	mA
	TEN 15-xx11	300		2500	
	TEN 15-xx12	125		1250	
	TEN 15-xx13	100		1000	
	TEN 15-xx21	±150		±1500	
	TEN 15-xx22	±62		±625	
	TEN 15-xx23	±50		±500	
Output Over Voltage Protection Zener diode clamp	TEN 15-xx10			3.9	Vdc
	TEN 15-xx11			6.2	
	TEN 15-xx12			15	
	TEN 15-xx13			18	
Output Over Current Protection	TEN 15-xx10			6000	mA
	TEN 15-xx11			4500	
	TEN 15-xx12			1875	
	TEN 15-xx13			1500	
	TEN 15-xx21			±2250	
	TEN 15-xx22			±938	
	TEN 15-xx23			±750	
Output Capacitor Load	TEN 15-xx10			10200	µF
	TEN 15-xx11			7050	
	TEN 15-xx12			1035	
	TEN 15-xx13			705	
	TEN 15-xx21			±1020	
	TEN 15-xx22			±495	
	TEN 15-xx23			±165	

Input Specifications					
Parameter	Device	Min	Typ	Max	Unit
Operating Input voltage	TEN 15-12xx TEN 15-24xx TEN 15-48xx	9 18 36	12 24 48	18 36 75	Vdc
Input reflected ripple current (please see the testing configurations part.)	All		20		mA pk-pk
Start up time (nominal V_{in} and constant resistive load power up)	All		20		mS

General Specifications					
Parameter	Device	Min	Typ	Max	Unit
Efficiency Test at $V_{in\,nom}$ and full load (Please see the testing configurations part.)	TEN 15-1210 TEN 15-1211 TEN 15-1212 TEN 15-1213 TEN 15-1221 TEN 15-1222 TEN 15-1223 TEN 15-2410 TEN 15-2411 TEN 15-2412 TEN 15-2413 TEN 15-2421 TEN 15-2422 TEN 15-2423 TEN 15-4810 TEN 15-4811 TEN 15-4812 TEN 15-4813 TEN 15-4821 TEN 15-4822 TEN 15-4823		79 82 86 86 83 86 84 80 84 85 85 84 86 86 81 83 87 86 85 88 87		%
Isolation resistance	All	>10			MΩ
Isolation Capacitance	All		300		pF
Switching Frequency (Test at $V_{in\,nom}$ and full load)	All		500		KHz
Weight	All		27		g
MTBF (see the MTBF and reliability part at page 23)	All		2'041'000		hours

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 120~140 percent of rated current (@ $V_{in\,nom}$). 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 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 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 low level, so reducing power dissipation ad case temperature in the device.

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.

Solder, clearing, and drying considerations

Soldering:

Flow(wave) soldering: 250°C ±10°C less than 10 seconds (see below)

Soldering iron: 370°C ±10°C less than 5 seconds

Note: the pin of this module is coated with Tin. To assure the solder-ability, modules should be kept in their original shipping containers to provide adequate protection. Also, the storage environment shall be well controlled to protect the oxidation.

Cleaning process:

In aqueous cleaning, it is preferred to have an in-line cleaner system consisting of several cleaning stages (pre-wash, wash, rinse, final rinse, and drying). Deionizer (DI) water is recommend for aqueous cleaning; the minimum resistively level is 1MΩ-cm.

Tap-water quality varies per region in terms of hardness, chloride, and solid contents; therefore, the use of tap water is not recommended for aqueous cleaning.

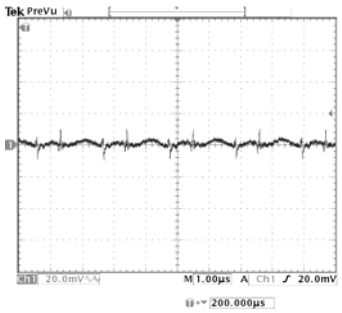
Drying:

The drying section of the cleaner system should be equipped with blowers capable of generating 1000 cfm-1500 cfm of air so that the amount of rinse water left to be dried off with heat is minimal. Handheld air guns are not recommended due the variability and consistency of the operation.

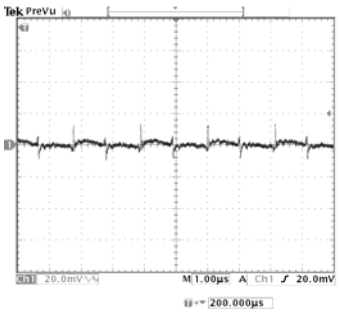
Note: after post-wash, the marking (date code) of converter may fall off. These only impacts the appearance and dose not affect the operation and not affect the operation of the module.

Output ripple & noise

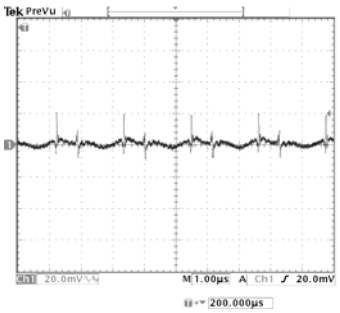
TEN 15-1211



Low Line, Full Load
Output Ripple Noise = 19.6mV pk-pk

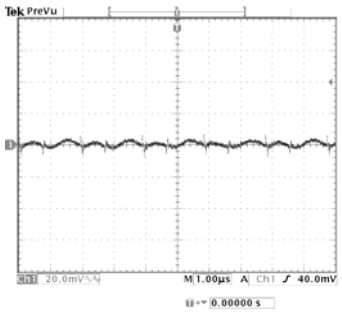


Normal Line, Full Load
Output Ripple Noise = 22.8mV pk-pk

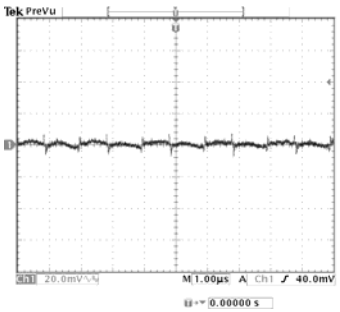


High Line, Full Load
Output Ripple Noise = 29.6mV pk-pk

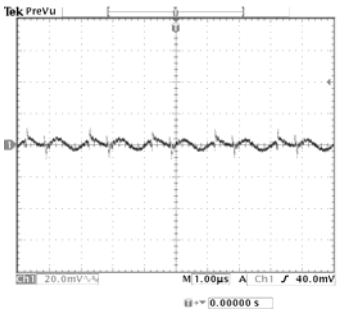
TEN 15-2410



Low Line, Full Load
Output Ripple Noise = 15.2mV pk-pk

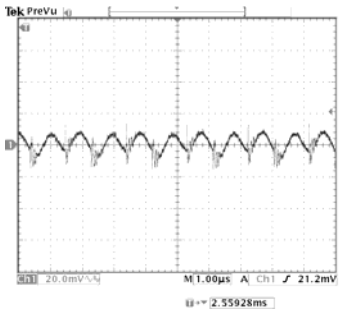


Normal Line, Full Load
Output Ripple Noise = 15.6mV pk-pk

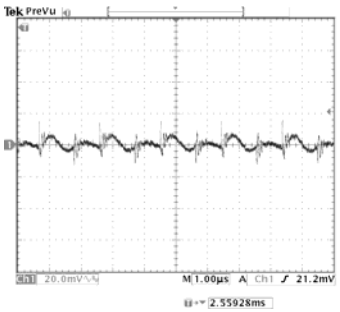


High Line, Full Load
Output Ripple Noise = 20.0mV pk-pk

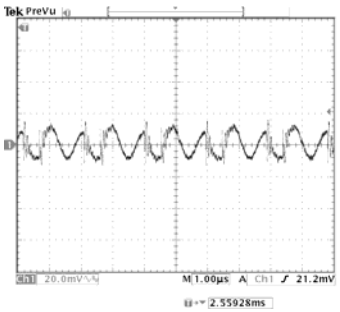
TEN 15-4812



Low Line, Full Load
Output Ripple Noise = 28. 4mV pk-pk



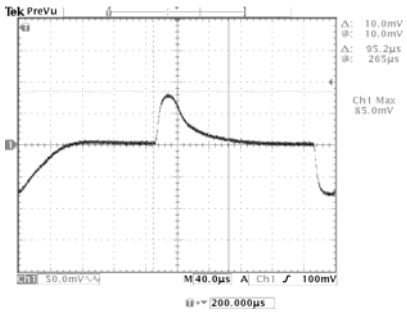
Normal Line, Full Load
Output Ripple Noise = 27.6mV pk-pk



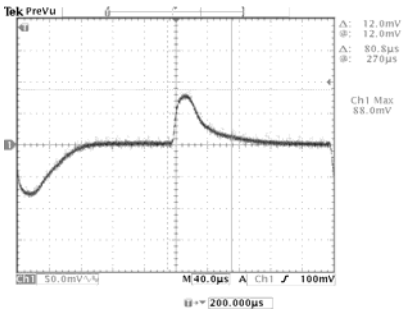
High Line, Full Load
Output Ripple Noise = 29.6mV pk-pk

Transient Peak and Response

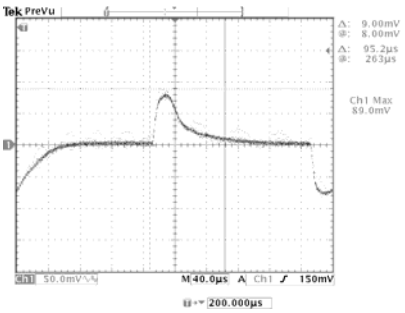
TEN 15-1211



Low Line, Full Load
Transient Peak 85.0mV
Transient Response 95.2µS

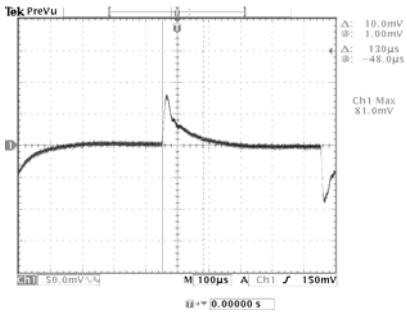


Normal Line, Full Load
Transient Peak 88.0mV
Transient Response 80.8µS

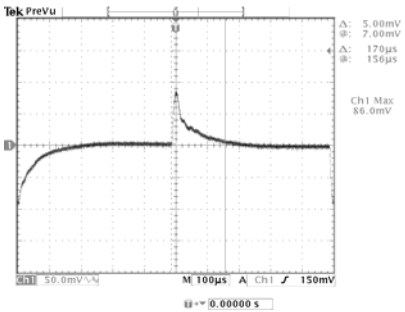


High Line, Full Load
Transient Peak 89.0mV
Transient Response 95.2µS

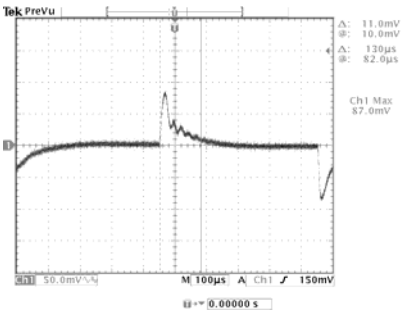
TEN 15-2410



Low Line, Full Load
Transient Peak 81.0mV
Transient Response130µS

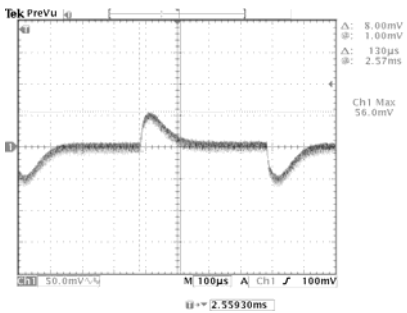


Normal Line, Full Load
Transient Peak 86.0mV
Transient Response 170µS

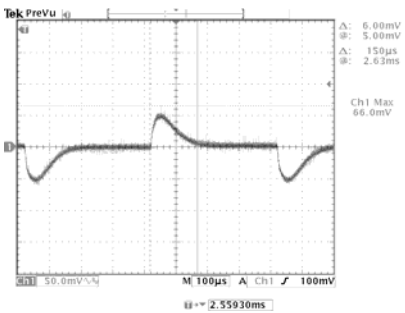


High Line, Full Load
Transient Peak 45.6mV
Transient Response 200µS

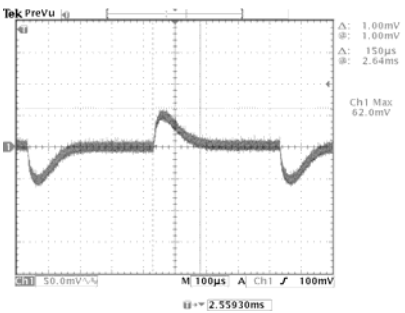
TEN 15-4812



Low Line, Full Load
Transient Peak 56mV
Transient Response130µS



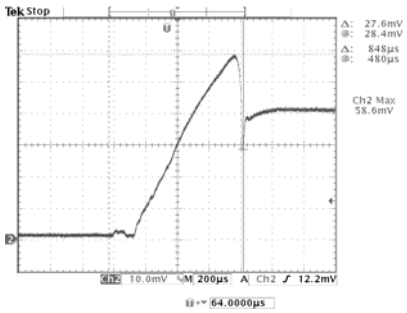
Normal Line, Full Load
Transient Peak 66mV
Transient Response 150µS



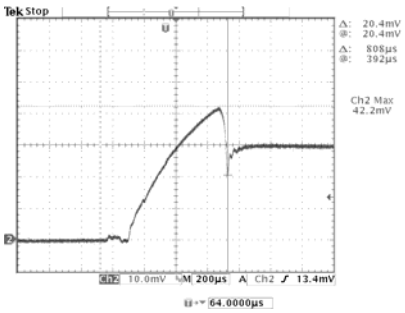
High Line, Full Load
Transient Peak 62mV
Transient Response 150µS

Inrush Current

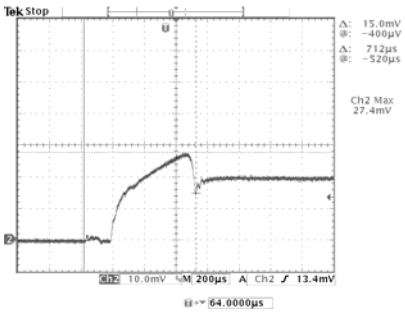
TEN 15-1211



Low Line, Full Load
Inrush current = 2930mA
Duration: 848µS

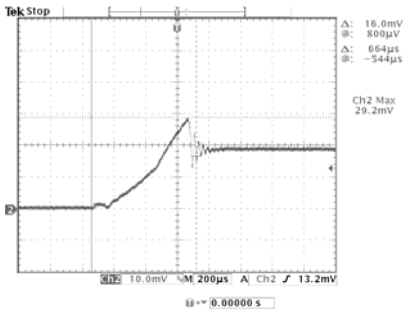


Normal Line, Full Load
Inrush current = 2210mA
Duration: 808µS

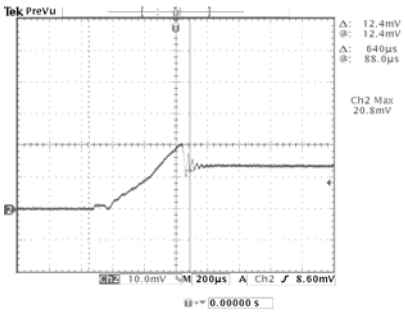


High Line, Full Load
Inrush current = 1370mA
Duration: 712µS

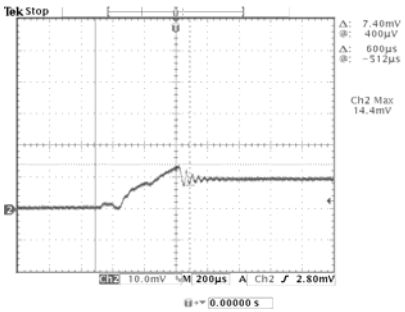
TEN 15-2410



Low Line, Full Load
Inrush current = 1460mA
Duration: 664µS

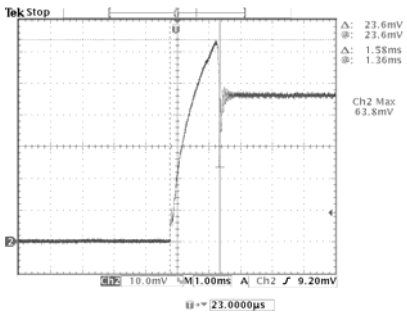


Normal Line, Full Load
Inrush current = 1040mA
Duration: 640µS

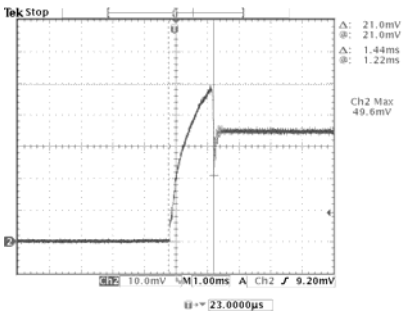


High Line, Full Load
Inrush current = 720mA
Duration: 600µS

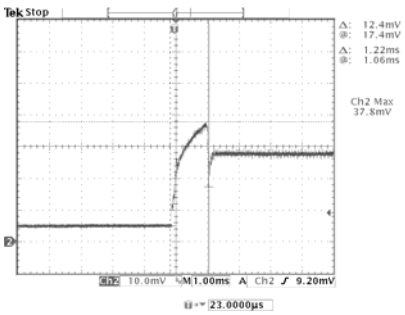
TEN 15-4812



Low Line, Full Load
Inrush current = 638mA
Duration: 1.58mS



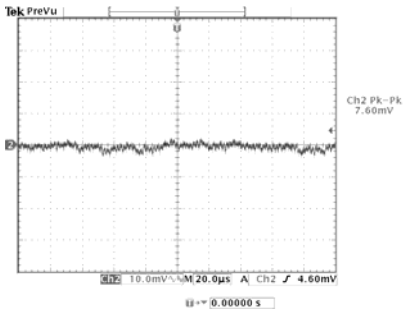
Normal Line, Full Load
Inrush current = 496mA
Duration: 1.44mS



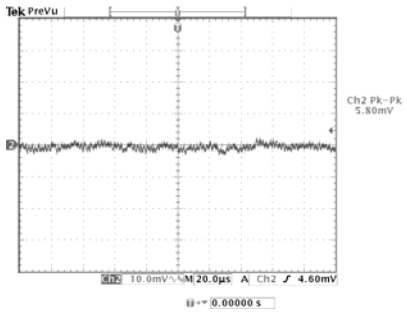
High Line, Full Load
Inrush current = 378mA
Duration: 1.22mS

Input Ripple Current

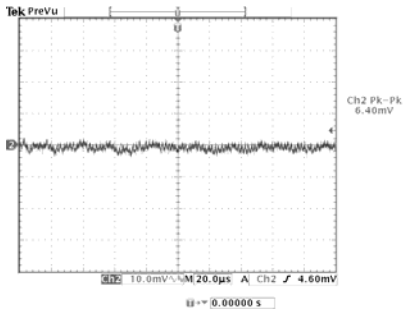
TEN 15-1211



Low Line, Full Load
Ripple current = 3.8mA

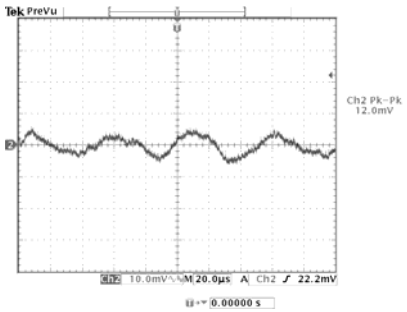


Normal Line, Full Load
Ripple current = = 2.9mA

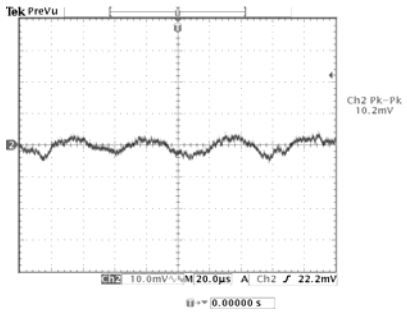


High Line, Full Load
Ripple current = 3.2mA

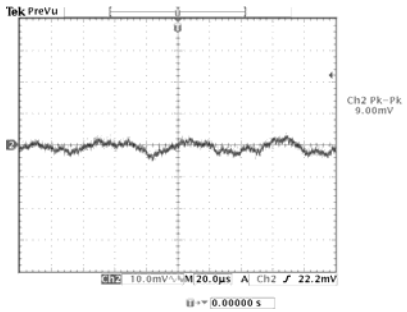
TEN 15-2410



Low Line, Full Load
Ripple current = 6.0mA

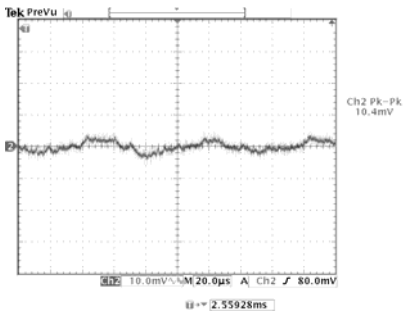


Normal Line, Full Load
Ripple current = 5.1mA

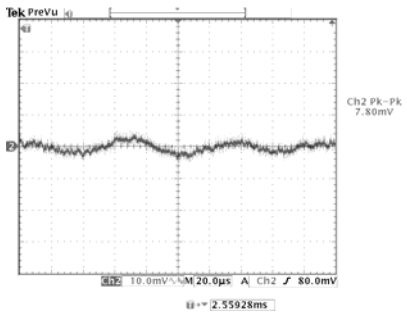


High Line, Full Load
Ripple current = 4.5mA

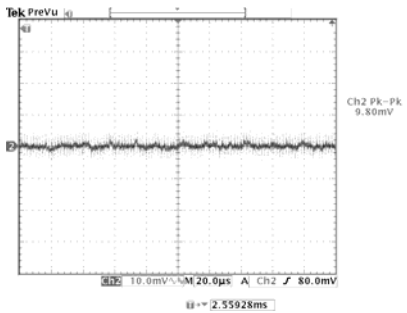
TEN 15-4812



Low Line, Full Load
Ripple current = 5.2mA



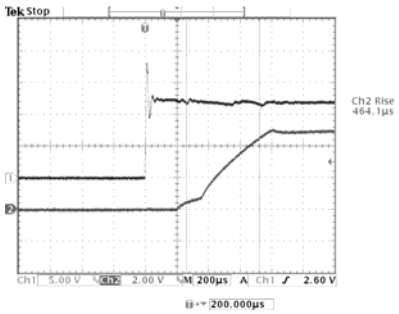
Normal Line, Full Load
Ripple current = 3.9mA



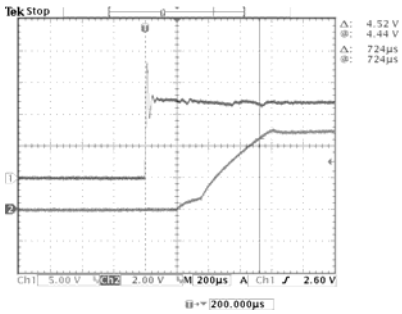
High Line, Full Load
Ripple current = 4.9mA

Delay Time and Raise Time

TEN 15-1211

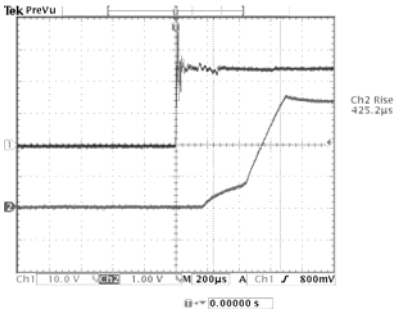


Normal Line, Full Load
Rise Time = 464.1µS

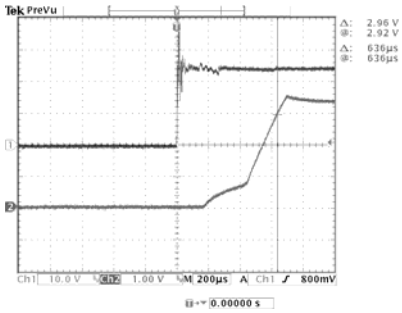


Nominal Line, Full Load
Delay Time = 724µS

TEN 15-2410

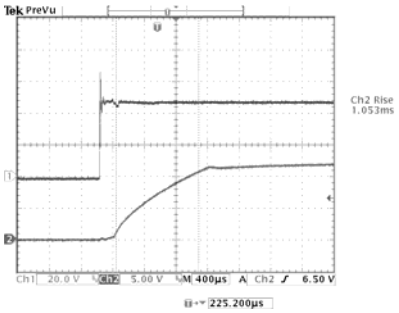


Normal Line, Full Load
Rise Time = 425.2µS

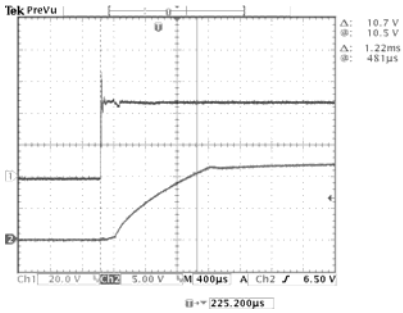


Normal Line, Full Load
Delay Time = 636µS

TEN 15-4812



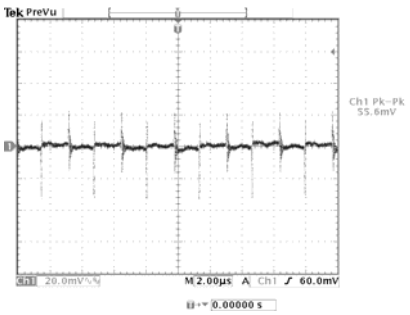
Normal Line, Full Load
Rise Time = 1.053mS



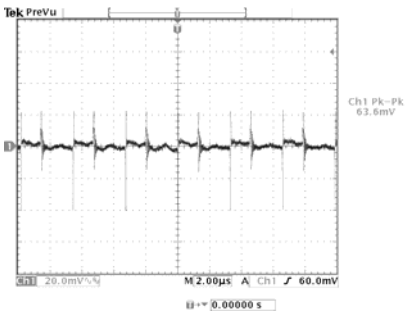
Normal Line, Full Load
Delay Time = 1.22mS

Output ripple & noise

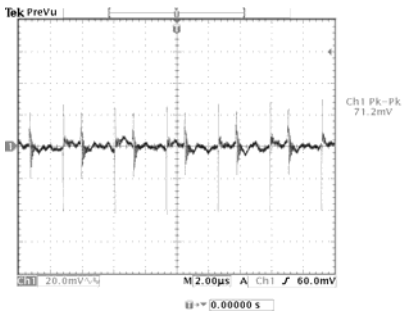
TEN 15-1221



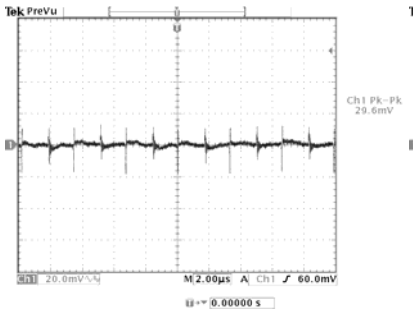
Low Line, Full Load
+5V = 55.6mV pk-pk



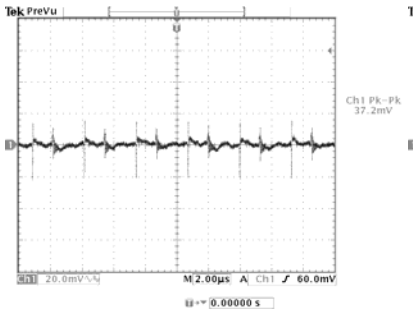
Normal Line, Full Load
+5V = 63.6mV pk-pk



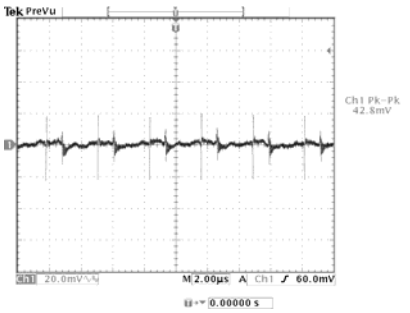
High Line, Full Load
+5V = 71.2mV pk-pk



Low Line, Full Load
-5V = 29.6mV pk-pk

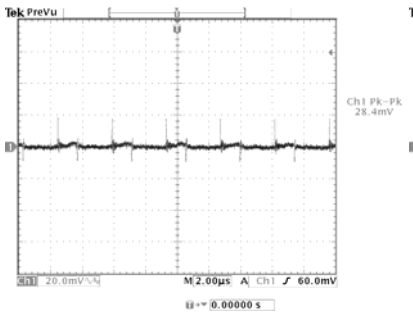


Normal Line, Full Load
-5V = 37.2mV pk-pk

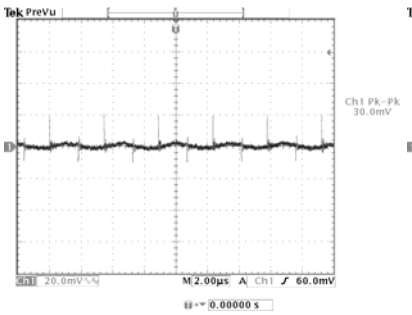


High Line, Full Load
-5V = 42.8mV pk-pk

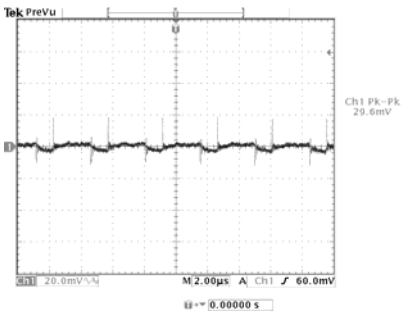
TEN 15-2422



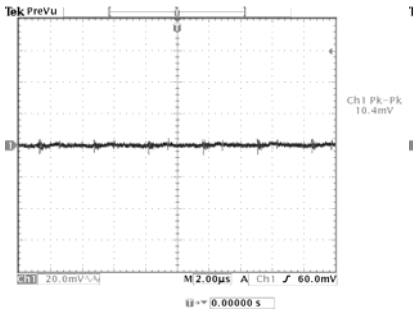
Low Line, Full Load
+12V = 28.4mV pk-pk



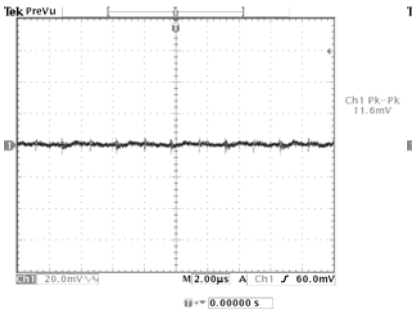
Normal Line, Full Load
+12V = 30.0mV pk-pk



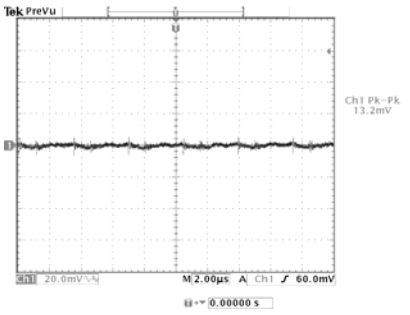
High Line, Full Load
+12V = 29.6mV pk-pk



Low Line, Full Load
-12V = 10.4mV pk-pk



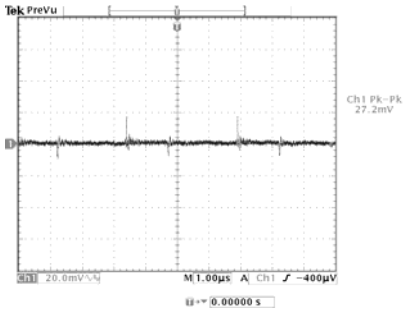
Normal Line, Full Load
-12V = 11.6mV pk-pk



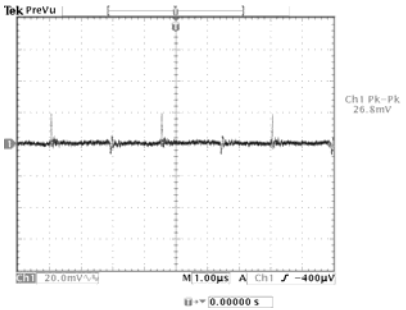
High Line, Full Load
-12V = 13.2mV pk-pk

Output ripple & noise

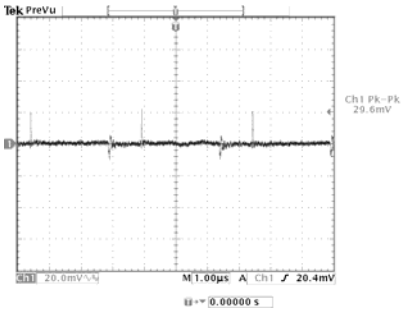
TEN 15-4823



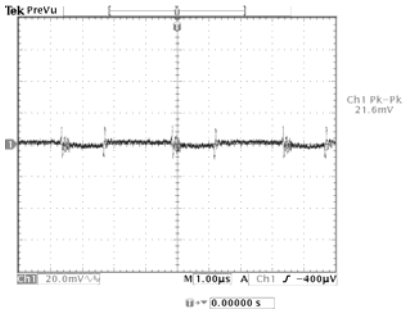
Low Line, Full Load
+15V = 27.2mV pk-pk



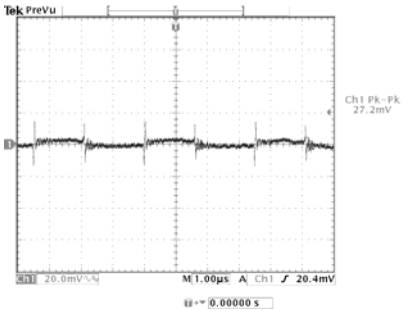
Normal Line, Full Load
+15V = 26.8mV pk-pk



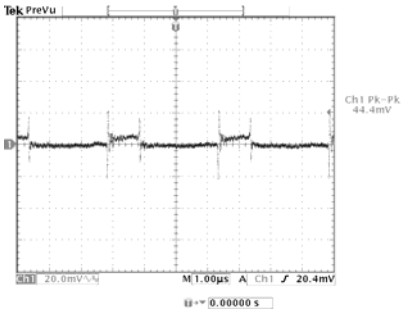
High Line, Full Load
+15V = 29.6mV pk-pk



Low Line, Full Load
-15V = 21.6mV pk-pk



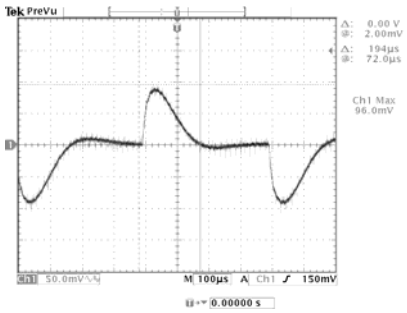
Normal Line, Full Load
-15V = 27.2mV pk-pk



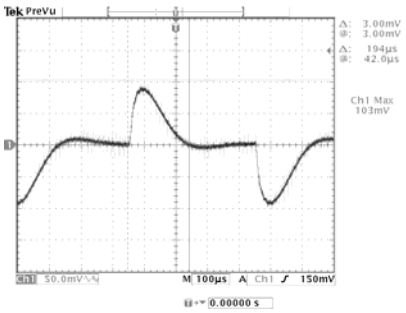
High Line, Full Load
-15V = 44.4mV pk-pk

Transient Peak and Response

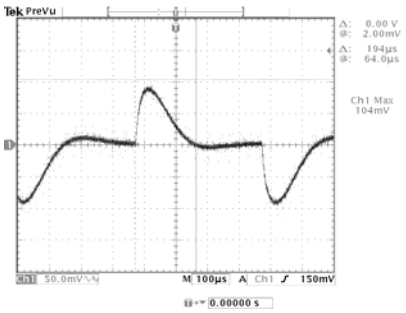
TEN 15-1221



Low Line, Full Load
Transient Peak 96.0mV
Transient Response 194µS

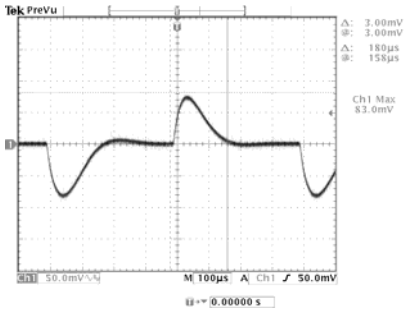


Normal Line, Full Load
Transient Peak 103.0mV
Transient Response 194µS

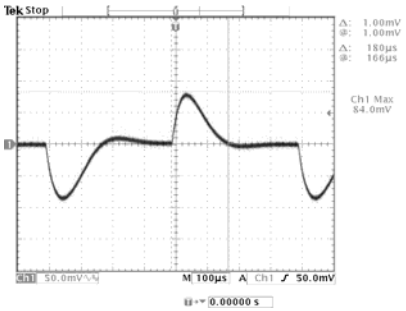


High Line, Full Load
Transient Peak104.0mV
Transient Response 194µS

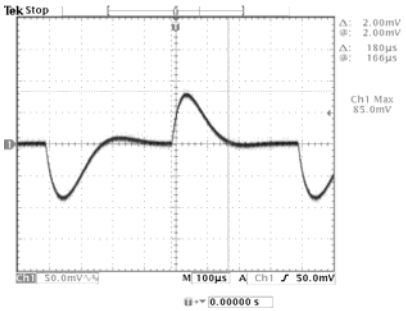
TEN 15-2422



Low Line, Full Load
Transient Peak 96.0mV
Transient Response 180µS

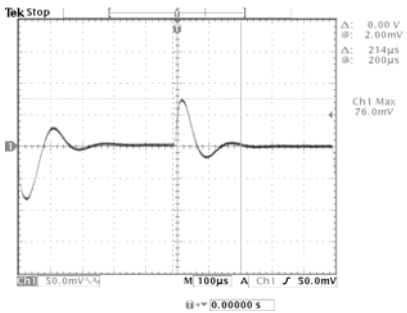


Normal Line, Full Load
Transient Peak 103.0mV
Transient Response180µS

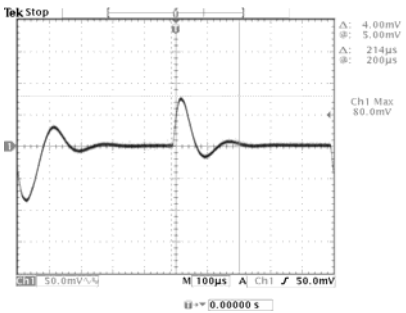


High Line, Full Load
Transient Peak104.0mV
Transient Response 180µS

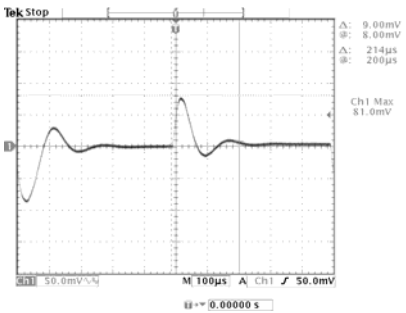
TEN 15-4823



Low Line, Full Load
Transient Peak 96.0mV
Transient Response 214µS



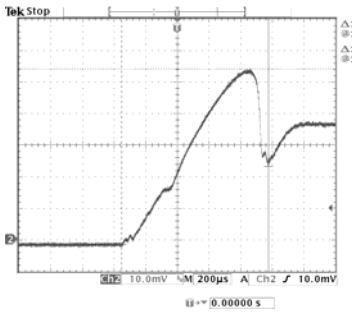
Normal Line, Full Load
Transient Peak 103.0mV
Transient Response 214µS



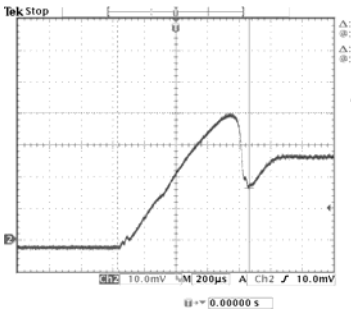
High Line, Full Load
Transient Peak104.0mV
Transient Response 214µS

Inrush Current

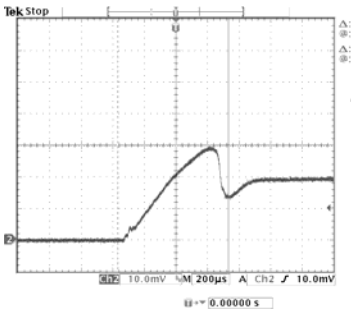
TEN 15-1221



Low Line, Full Load
Inrush current = 2700mA
Duration: 928µS

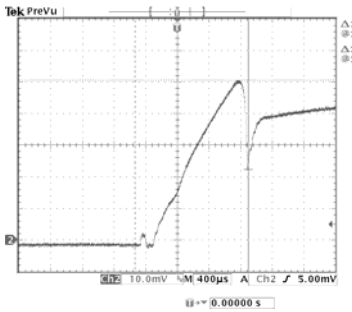


Normal Line, Full Load
Inrush current = 2000mA
Duration: 836µS

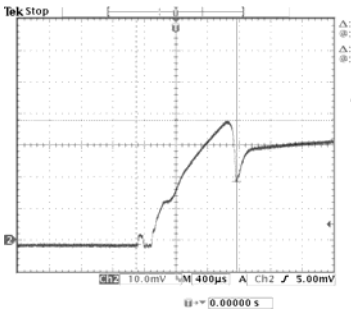


High Line, Full Load
Inrush current = 1470mA
Duration: 700µS

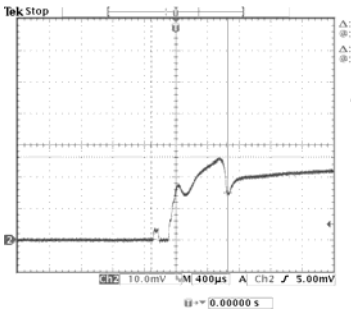
TEN 15-2422



Low Line, Full Load
Inrush current = 1012mA
Duration: 1.43mS

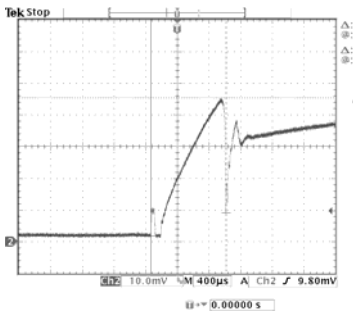


Normal Line, Full Load
Inrush current = 756mA
Duration: 1.27mS

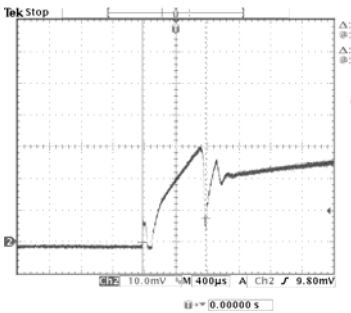


High Line, Full Load
Inrush current = 524mA
Duration: 988µS

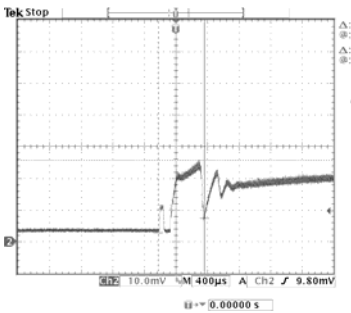
TEN 15-4823



Low Line, Full Load
Inrush current = 454mA
Duration: 952µS



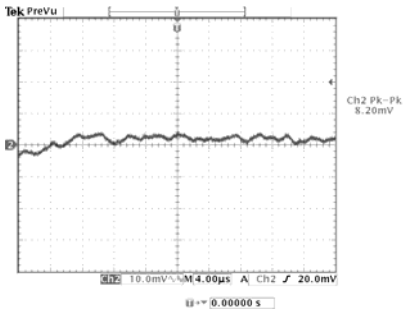
Line, Full Load
Inrush current = 300mA
Duration: 800µS



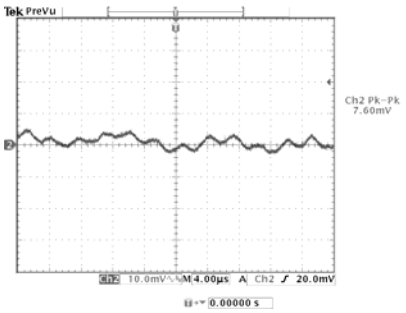
High Line, Full Load
Inrush current = 256mA
Duration: 584µS

Input Ripple Current

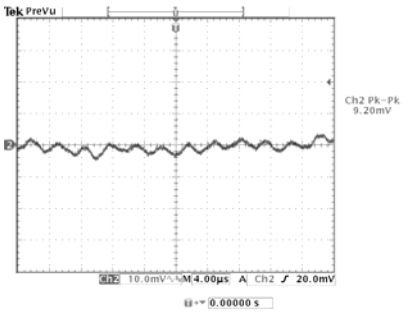
TEN 15-1221



Low Line, Full Load
Ripple current = 4.1mA

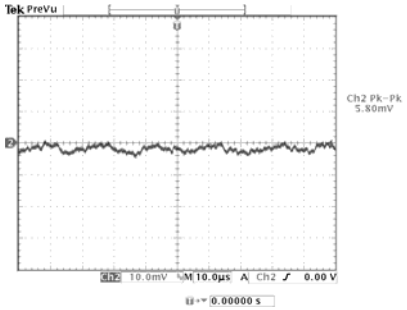


Normal Line, Full Load
Ripple current = 3.8mA

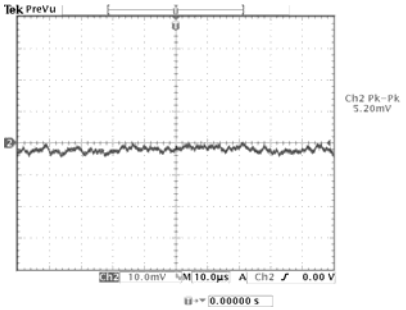


High Line, Full Load
Ripple current = 4.6mA

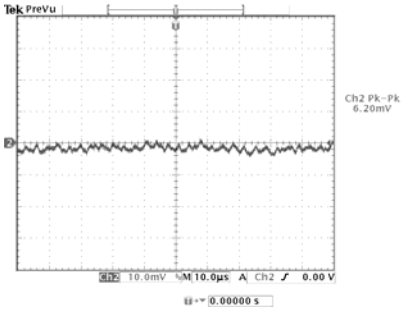
TEN 15-2422



Low Line, Full Load
Ripple current = 2.9mA

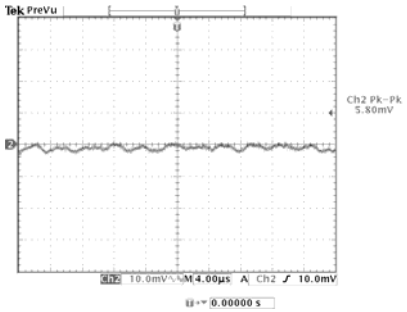


Normal Line, Full Load
Ripple current = 2.6mA

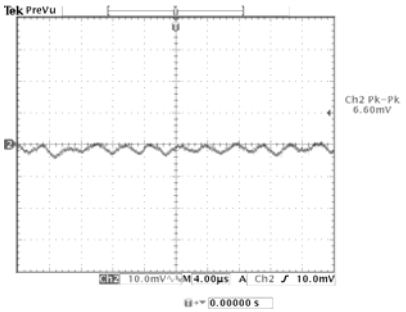


High Line, Full Load
Ripple current = 3.1mA

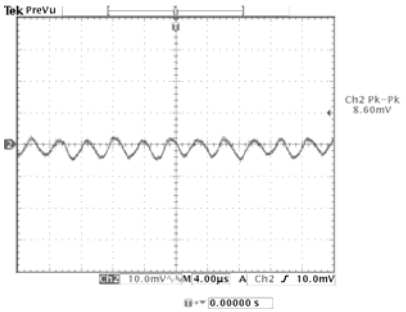
TEN 15-4823



Low Line, Full Load
Ripple current = 2.9mA



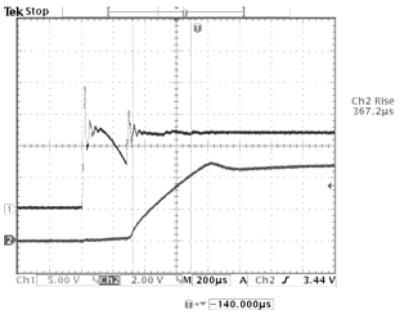
Normal Line, Full Load
Ripple current = 3.3mA



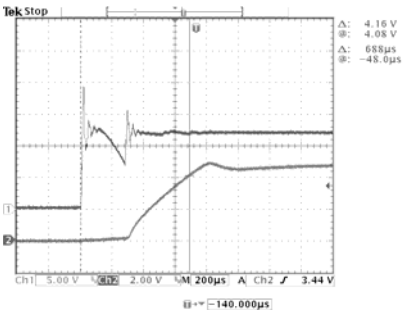
High Line, Full Load
Ripple current = 4.3mA

Delay Time and Rise Time

TEN 15-1221

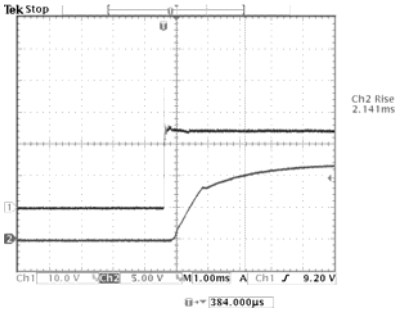


Normal Line, Full Load
Rise Time = 367.2µS

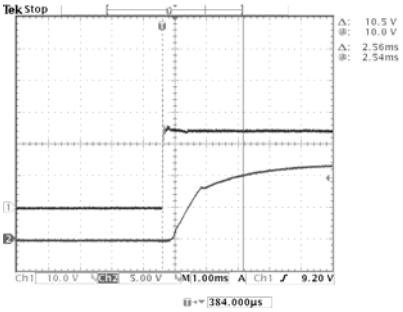


Normal Line, Full Load
Delay Time = 688µS

TEN 15-2422

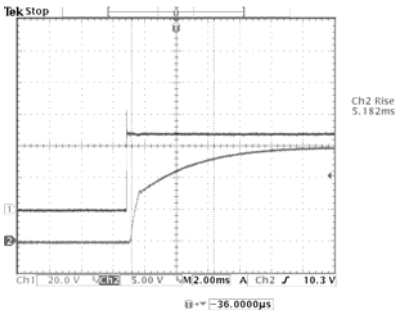


Normal Line, Full Load
Rise Time = 2.141mS

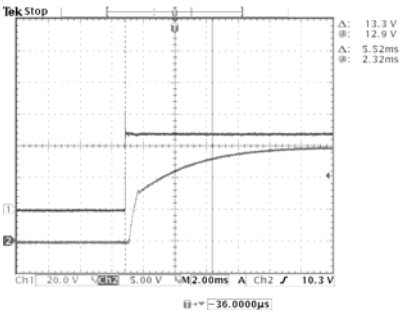


Normal Line, Full Load
Delay Time = 2.56mS

TEN 15-4823



Normal Line, Full Load
Rise Time = 5.182mS



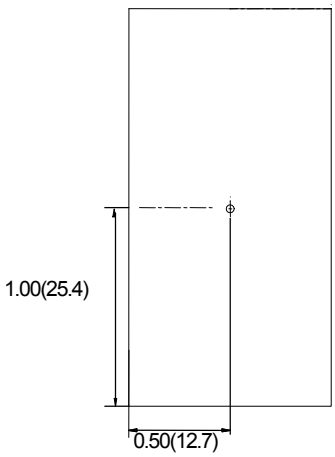
Normal Line, Full Load
Delay Time = 5.52mS

Thermal Consideration

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convention, and radiation to the surrounding environment. Proper cooling can be verified by measuring the case temperature (Tc) should be measured at the position indicated in right figure

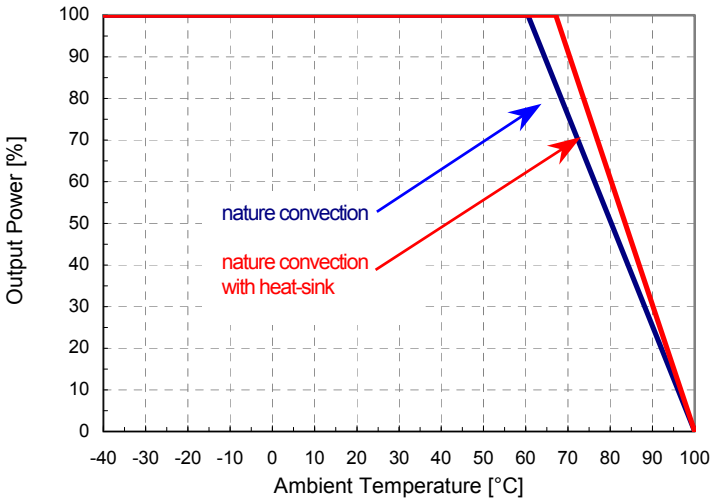
The temperature at this location should not exceed 100˚C. When operating the power module, adequate cooling must be provided to maintain the power module case temperature at or below 100˚C.

Although the maximum case temperature to lower value for extremely high reliability. Optimum cooling is obtained with forced convention.



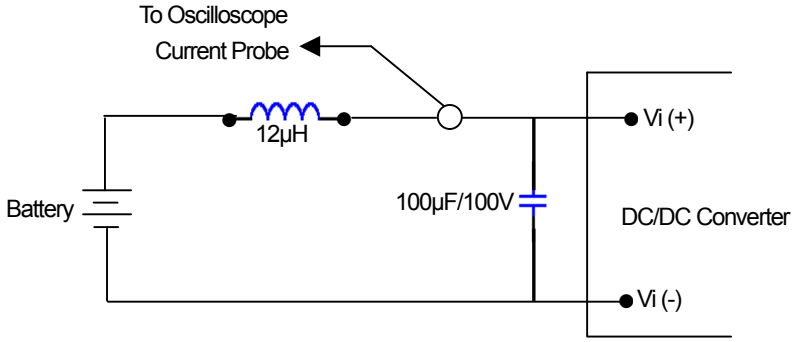
Following are derating curve for TEN 15-1211, TEN 15-2410, TEN 15-4812

TEN 15-1211

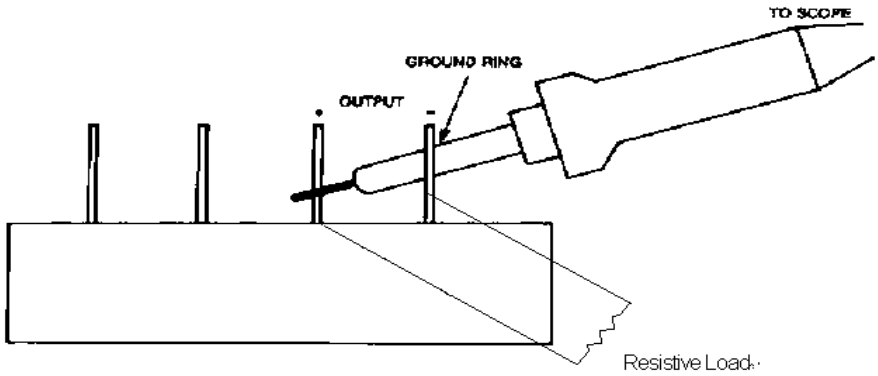


Testing Configurations

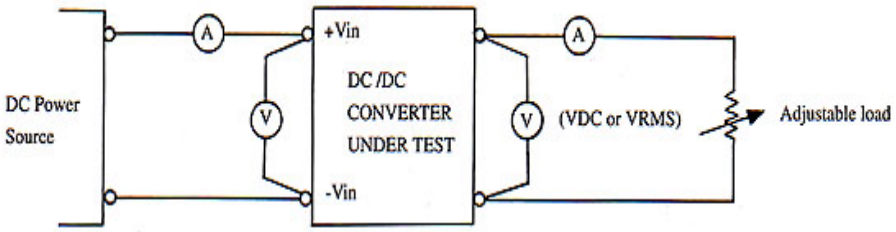
Input reflected-ripple current Measurement Test up



Peak-to-peak output ripple & noise Measurement Test up



Output Voltage and Efficiency Measurement Test up

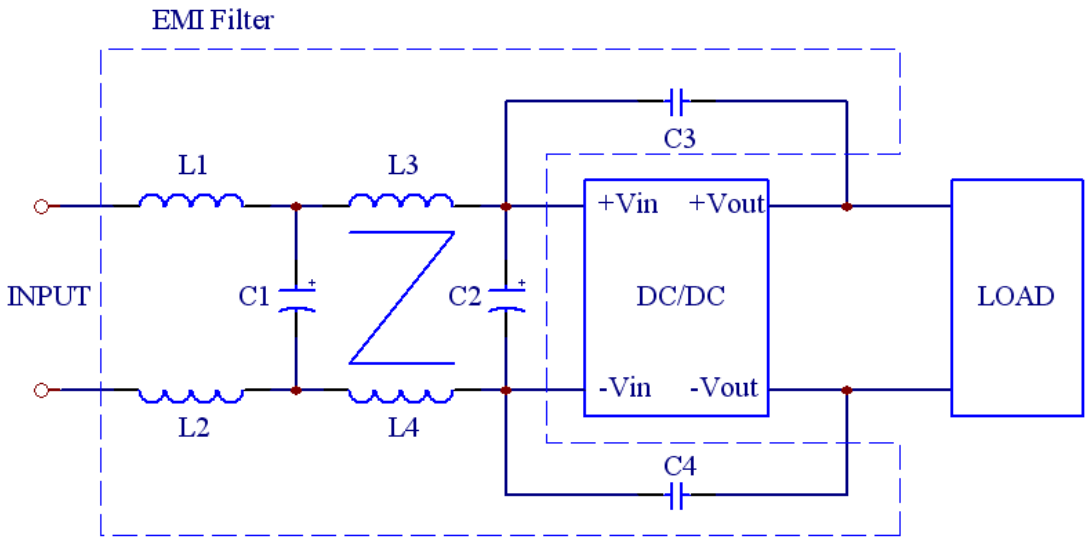


Note: All measurements are taken at the module terminals.

$$\eta = \left\{ \frac{V_{out} \times I_{out\,max}}{V_{in\,nom} \times I_{in}} \right\} \times 100\%$$

EMC Consideration				
EN61000-4-2 ESD	Contact discharge		Air discharge	
	level	test voltage(KV)	level	test voltage(KV)
	1	±2	1	±2
	2	±4	2	±4
	3	±6	3	±8
	4	±8	4	±15
EN61000-4-3 RS	level	test field strength (V/m)		
	1	1		
	2	3		
	3	10		
EN61000-4-4 EFT	open circuit output test voltage ±10%			
	level	power line		
	1	±0.5KV		
	2	±1.0KV		
	3	±2.0KV		
	4	±4.0KV		
EN61000-4-5 Surge	level	open circuit output test voltage ±10%		
	1	±0.5KV		
	2	±1.0KV		
	3	±2.0KV		
	4	±4.0KV		
EN61000-4-6 CS	level	voltage level (EMF)		
	1	1V/rms		
	2	3V/rms		
	3	10V/rms		

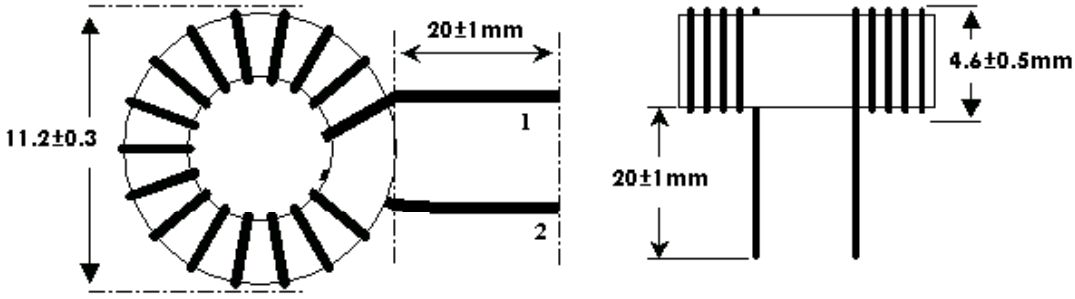
EMI Filter



1. L1 = L2: Common choke P/N.9L-TF016, as attachment 1.
2. L3 = L4: Common choke Common choke P/N.9L-TF017, as attachment 2.

1. L1 = L2: Common choke P/N.9L-TF016 as **attachment 1.**
2. L3 = L4: Common choke Common choke P/N.9L-TF017 as **attachment 2.**
3. C1 = C2: (1)To lie down NIPPON CHEMI-CON KMF series 100µF/50V aluminum electrolytic capacitors 8mm x 11.5mm(ΦD x L) or equivalent for 12 & 24Vin.
   (2) To lie down NIPPON CHEMI-CON KMF series 22µF/100V aluminum electrolytic capacitors 8mm x 11.5mm(ΦD x L) or equivalent for 48Vin.
4. C3=C4: 1000pF/2KV DIP or SMD MLCC.

attachment 1 9L-TF016



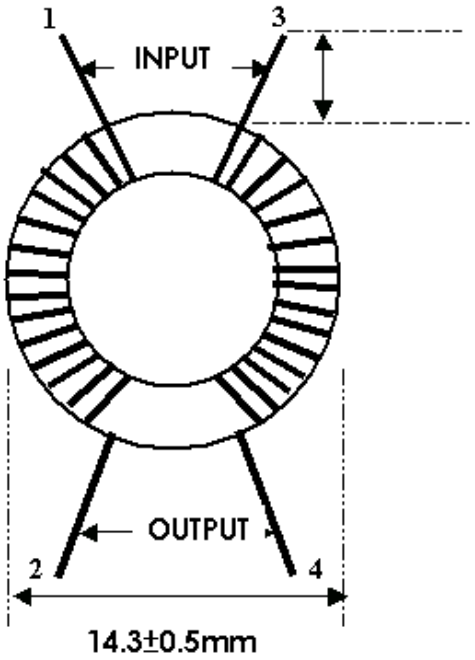
Material: Core: 9 x 5 x 3 Wire: 2-UEW Φ 0.5mm

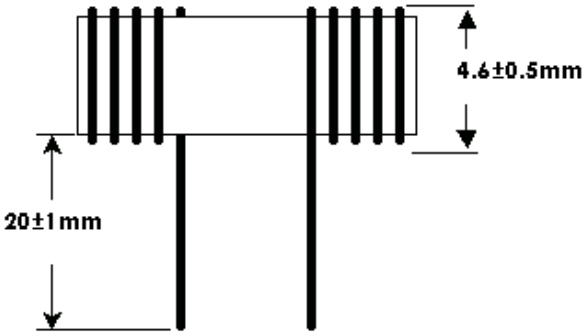
Specifications: inductance
pin 1-2: 300µH±35%
DCR: 32mΩ Max.

Test condition: 100KHz/20mV

Measurement instrument: HP 4263B LCR Meter

attachment 2 9L-TF017





Material: Core: 13 x 8 x 6 Wire: 2-UEW Φ 0.5mm

Specifications: inductance pin 1-2: 900µH Min.
pin 3-4: 300µH Min.
DCR: 45mΩ Max.

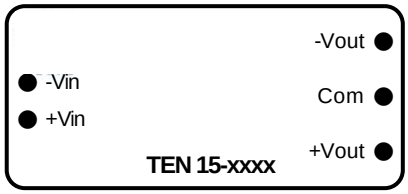
Test condition: 100KHz/100mV

Measurement instrument: HP 4263B LCR Meter

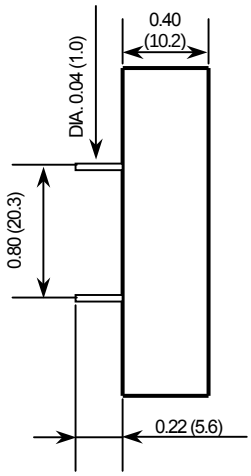
Mechanical Data

Dimensions are in millimeters and(inches)
Tolerances: x .xx in. ±0.020 in. (x.x mm ±0.5mm)
x .xx in. ±0.015 in. (x.x mm ±0.5mm)
Pin Pitch Tolerance: ±0.014 (±0.35)

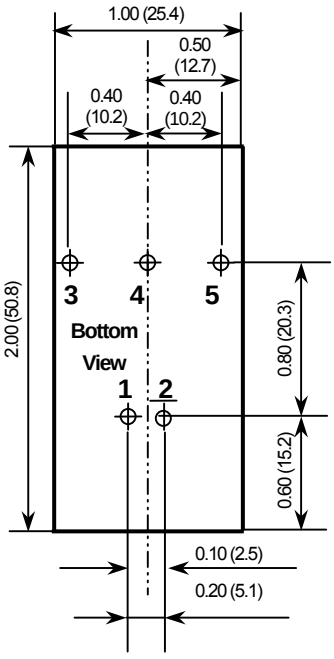
Top View



Side View



Bottom View



PIN CONNECTION		
PIN	Single Output	Dual Output
1	+ INPUT	+ INPUT
2	- INPUT	- INPUT
3	+ OUTPUT	+ OUTPUT
4	NO PIN	COMMON
5	- OUTPUT	- OUTPUT

Safety and Installation Instruction

Isolation consideration

The TEN 15 series features 1.5kVdc isolation from input to output, input to case, and output to case. The input to output resistance is greater than 10^9 ohms. Nevertheless, if the system using the power module needs to receive safety agency approval, certain rules must be followed in the design of the system using the model. In particular, all of the creepage and clearance requirements of the end-use safety requirement must be observed. These documents include UL 60950-1, EN 60950-1 and CSA 22.2 60950-1-2, although specific applications may have other or additional requirements.

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 a 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 slow-blow fuse with maximum rating of 6.3 A. 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.

Minimum Load Requirement

10% (of full load) minimum load required. The 10% minimum load requirement is in order to meet all performance specifications. The TEN 15 Series does not properly maintain regulation and operate with no load condition. The output voltage drops off about 10%.

MTBF and Reliability

The MTBF of TEN 15 series of DC/DC converters has been calculated using

1. MIL-HDBK-217F under the following conditions:
   Nominal Input Voltage
   $I_{out} = I_{out\,max}$
   $T_A = 25°C$
   The resulting figure for MTBF is 1'044'000 hours.

2. Bellcore TR-NWT-000332 Case I:
   50% stress, Operating Temperature at 40°C (Ground fixed and controlled environment)
   The resulting figure for MTBF is 2'041'000 hours.