Power Supply Test Report

A1 POWER ENGINEERING

Project reference	**:** XXXXXXX
Report Number	**:** XXXXXXXX
Issue Date	**:** 2nd January 2007
Issue Number	**:** 1

Manufacturer	**:** XXXXXX
Models	**:** XXXXXXXXXXX
Product Description	**:** AC – DC Power Supply
Electrical Ratings	**:** 90 - 264VAC 100W with 5CFM
Operating Conditions	**:** Continuous

Standards Applied	**:** EN 60950

Prepared By :	**Reviewed By :**
XXXXXXX Principle Engineer	XXXXXXX XXXXXXXXX

Power Supply Test Report

Contents

Product Summary

The product provides four fully regulated DC outputs from an AC source of 90-264Vac at 50Hz.

Output ratings are :

V1 = 5Vdc @XXA
V2 = 25Vdc @ XXA
V3 = +15Vdc @XXA
V4 = -15Vdc @ XXA

The topology consists of two flyback converters running in parallel with each providing two dc outputs in each case. The first provides the 5V and +15V, with the second providing the 24V and –15V. Each converter consists of a single FET drive front end with control via a UC3843 PWM IC.

The PWM is managed in each case by sensing either the 5V or 24V respectively with +/-15V outputs being further post regulated via discrete devices for improved stability.

The product does not incorporate either passive or active power factor correction and whilst should meet the EMC Harmonic requirements of EN61000-3-2 class A, would be unlikely to meet the requirements of EN61000-3-2 class D.

Testing - General

Testing was carried out using calibrated 6 digit Keithley 195 dvm, four 100W electronic loads, Tektronix TDS220 digital oscilloscope, Meterman thermometer, 100KHz active ac current probe for inrush current, Tektronix current probe type P6021, Voltech AC power analyser, Megger FT6/12 flash tester.

The product was tested in a controlled environment with an ambient temperature of 25°C. Based upon the manufacturers specification for derating, thermal testing of critical components was carried out at two levels. The outputs were loaded to 80W for convection cooling applications and 100W for assisted cooling via 5cfm airflow
(simulated – see test 13).

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1) 230Vac Setup and adjustment tolerance

With outputs loaded to 100W measurements were taken as below :

V1 5V @ XXA = XXVdc
V2 24V @ XXA = XXVdc
V3 +15V @ XXA= XXVdc
V4 –15V @ XXA = XXVdc

Adjustment is provided for the 5Vdc output only with all other outputs fixed.
The 5Vdc output adjusts within the limits : 4.58 – 5.6Vdc (within specification).
Note : No remote sensing is provided within this product for output lead compensation

2) Overvoltage protection (OVP)

Overvoltage protection is provided by monitoring the 5Vdc output in the event that the PWM control loop of the product should fail.

The 5Vdc output was programmed to increase outside the normal operating range of product to operate the OVP circuitry. The OVP was found to operate at 6.5Vdc (within specification). The OVP operation shuts down the psu completely requiring a mains reset and delay of 1 minute to restart.

3) Input line regulation / AC input operating range

With output loads applied as below (100W) the input voltage was varied from 90 – 264Vac. Output voltages were measured and found to be consistent over input range as below :

V1 5V @ 9.3A = XXVdc
V2 24V @ 1.6A = XXVdc
V3 +15V @ 0.6A = XXVdc
V4 –15V @ 0.4A = XXVdc

The above test was then repeated with zero loading applied and outputs measured. The output voltages remained as above (within specification).

4) Output load regulation

With output loads applied as below each output was varied from minimum to maximum (with other outputs @ 50% load) and measured as below (within specification):

V1 5V @ 0 - XXA variation < 0.1%
V2 24V @ 0 - XXA variation < 0.1%
V3 +15V @ 0 - XXA variation < 0.1%*
V4 –15V @ 0 - XXA variation < 0.1%**

* A minimum load of 1A is required on 5V output to support +15V @ 0.8A
** No minimum load required on 24V output to support –15V @ 0.5A

5) Dynamic response

Using a switched electronic load the 5Vdc output was pulse loaded with loading switching between 2A (20%) and 10A.(100%). The dynamic response of the main PWM control loop was then tested by varying the switching frequency of the load from DC to 1KHz and the output remained relatively stable within +/-0.4Vdc during load transition which recovered within 100uS.

Measurements at 1kHz are shown in Appendix A , Fig 6.

6) Output ripple and noise (DC to 30MHz and RMS)

The ripple and noise was measured for each output using a x1 measurement probe with maximum output load applied in each case. No external capacitance was applied.

Ripple and Noise is within product specification. Measurements taken for each output are shown in Appendix A, Figs 1,2,3,4 & 5.

7) Input current, efficiency and power factor

With outputs loaded to 100W the input current, input power and power factor was measured at 115Vac and 230Vac. All measurements are within specification.

Measurements taken are shown in Appendix A, Figs 19 & 20.
Efficiency typically measured at 80-81% with lagging PFC @ 0.58-0.62.

8) Output hold up

With outputs loaded to 100W the 5Vdc output was measured relative to the AC mains input when mains disconnected to confirm hold up time. The test was repeated at 115Vac and 230Vac and found to be within specification with hold up typically 20mS from 115Vac and 85mS from 230Vac input.

Measurements taken are shown in Appendix A, Figs 13 & 14.

9) Inrush current

With outputs loaded to 100W the AC input inrush current was measured at switch on at both 115Vac and 230Vac input. At 230Vac the inrush did measure outside of specification(44A measured – 40A specified) but this is subject to mains cycle at switch on. Measurements taken are shown in Appendix A, Figs 11 & 12.

10) Stress on primary switching FET's

Devices : Q1 & Q8
Type : International Rectifier IRFIB6N60A rated at 6A/600Vdc. See Appendix B for short data.

With outputs loaded to 100W the stress upon switching FET's Q1 and Q8 was measured via the drain voltage and source current in case at a nominal input voltage of 230Vac and again at 264Vac.

In each case both the voltage and current is within specification as per measurements shown within Appendix A Figs 7,8,9 & 10. However it was noticed that when increasing the input to 264Vac the peak of the drain voltage present at Q1 (+5V, +15V) was approaching maximum permissible of 600Vdc (580Vdc measured).

11) Stress on secondary rectifiers

Devices : CR2 & 3 : STPS3045CT 15A/45V schottky rectifier (5V output)
CR4 : MURF1620 16A/200V schottky rectifier (24V output)
SMT x 2 : MBRS190T3 1A/90V schottky rectifier (+/-15V outputs)
(See Appendix B for shortform data)

With 230Vac applied and maximum output load applied to each output in turn the peak voltage present across the corresponding rectifier in each case was measured and recorded as shown within Appendix A Figs 15, 16 ,17 & 18.

Whilst the 5V and 24V rectifiers measured well below the rated Vrrm in each case it was noted that with the +/-15V rectifiers, little or no margin was available to allow for input transients if taking into account inductive ringing present. The devices were operating close to the rated Vrrm of 90V – particularly at maximum rated input of 264Vac.

12) Output overload

The product does not incorporate secondary current limit protection other than the +/-15 outputs are post regulated via discrete devices with built in s/c protection.

The +5V and 24V output current is limited by the action of the primary power limit of each respective PWM converter.

In each case the output current was increased (with zero load on other outputs) until the output voltage started to foldback . The maximum current available in each case is recorded as below :

V1 5V = XXA*
V2 24V = XXA*
V3 +15V = XXA (possibility of rectifier exceeding rating**)
V4 –15V = XXA (possibility of rectifier exceeding rating**)

* Due to the maximum current available from these outputs before protection operates, there is a possibility of the corresponding power transformer overheating with possible breakdown (barrier components).

**The +/-15V rectifiers are rated for 2A operation @ 100 Deg°C and 1A operation @ 120 Deg°C. Taking into account the operating temperatures measured within section 13 at an ambient of 25 Deg°C it is likely that the temperature of these devices will exceed 100 Deg°C should the ambient temperature increase or the output become overloaded, with subsequent failure of the device.

Secondary rectifiers (not +/-15V) and regulators are heatsink mounted, the temperature of which is monitored via a 120 Deg°C thermostat which shuts down the product in the event of over temperature.

13) Thermal testing

In line with the manufacturers derating curve thermal testing of critical components was carried out with output loading to 80W for convection cooled applications and then repeated with output loading increased to 100W and fan cooling applied. The fan was placed to the side of the product at a distance of approximately 2cm. In each case the ambient room temperature was at 25 Deg°C.

Measurements were taken after a running period of 3 hrs continuous operation as below :

	(80W-convection)	**(100W with approx 5cfm)**
Q1 (+5/+15V primary switching FET)	= 75 °C	39 °C
Q8 (+24/-15V primary switching FET)	= 75 °C	53 °C
Output capacitors – general	= 95 °C to 100 °C	52 °C to 56 °C
T1 (+5/+15V TXR)	= 109 °C*	55 °C
T2 (+24/-15V TXR)	= 110 °C*	67 °C
Output rectifiers	= 90 to 94 °C	50 °C to 54 °C
PWM aux supply capacitors	= 85 °C	45 °C typ.

Fan assisted cooling method used :

*At 50 Deg°C ambient the temperature of these devices would increase to 134 / 135 Deg°C (higher in overload conditions). This would likely exceed the typical rating of such a device of 130 Deg°C. For UL/EN60950 the temperature should not exceed 105 Deg°C at maximum rated operating temperature (indeed it is good practice to add a further 10 Deg°C to measurements to allow for error.

All output capacitors are manufactured by Nichicon and of the PW type rated at 105 °C. Based upon the manufacturers data the expected lifespan of the types used is 3000hrs for 8mm diameter (used on +/-15V) and 5000hrs for 10mm diameter (used on 5/24V) based on operating at maximum operating temperature of 105 °C.

Based on figures obtained above it is concluded that when operating this product without convection cooling at 80W or above the lifespan of these (and indeed all) capacitors will be greatly reduced. The rated life expectancy of these capacitors, as a guide, is doubled for each reduction of 10°C below the maximum rated temperature of 105 °C.

14) Creepage and clearance – pcb and barrier transformers

Creepage and Clearance of the pcb and mounted components was checked with respect to input to output and input to earth and found to generally meet the requirements of EN60950 but with some concern.

Both power transformers (T1 & T2) were dismantled and the overall construction was found to be compliant. The primary winding in each case consists of enamelled copper wire with all leadouts suitably insulated. Polyester PLEO or similar barrier tape is used to reinforce primary to secondary insulation. The secondary windings in each case are polymer coated (or similar) to provide additional isolation.

Slight concern is shown with respect to the mounting of T1 to the pcb. Whilst the core of the T2 transformer is clear of the pcb (and insulated) the core of transformer T1 is mounted flat to the pcb and over lays both input and output pcb tracks.

The core is insulated with a single layer of proprietary polyester tape (or similar as unconfirmed without manufacturers data) and poorly finished. The typical breakdown voltage for such tape is 4kV. Clearly if this tape were to fail a current path from input to output may occur.

Furthermore, in reference to temperature tests carried out within section 13, the temperature rating of the pcb may be exceeded if the product is used to full capacity without fan cooling and at raised operating temperatures.

The tracks in question are shown below along with the underside of T1 (part of insulation was removed during testing):

15) Safety Isolation

The product was HI-POT tested using the DC equivalent of the AC safety isolation ratings stated within the product specification as the product incorporates 'Y' class capacitors for EMC purposes.

Tests carried out were as below :

Input to Earth @ 2.20KVdc
Input to output @ 5.6KVdc
Output to Earth @ 700Vdc

The product passed these tests but it should be noted the voltage ratings of the 'Y' and common mode capacitors is exceeded when conducting this test.

'Y' capacitors used = 330pF 400Vac
Output common mode capacitor = 3n3F @ 500Vdc

Secondary to primary control is maintained by the use of opto couplers type NEC PS2561 which have a breakdown voltage rating of 5kVac.

Conclusions

In our opinion the product may not meet the product specification with respect to the criteria tested herewith within this report though it should be stressed that certain component information is unavailable. General concerns are drawn to the following points :

- **Temperature** :

From the thermal tests carried out the product will clearly run hot when operated at 80W or above without fan cooling. Bearing in mind that the ambient temperature when taking measurements was 25 °C there will clearly be a subsequent rise in temperature of these components which will almost certainly exceed the component ratings in some instances (such as capacitors and possibly PCB temperature rating due to proximity of transformers). In particular the transformers which are safety barrier components may well exceed their temperature rating.

Due to the lack of secondary current limit it will be possible to overload both converters significantly causing further temperature rise and possible breakdown of the transformer isolation barrier if the wire insulation temperature is exceeded. Note- no thermal protection is provided within either transformer assembly. From measurements taken within section 12 it can be seen that the 5V converter would deliver 80W and the 24V converter (the smaller txr) would deliver 74W before primary current limit operates.

- **Isolation** :

The 5V transformer (T1) core overlays both primary and secondary pcb tracks with what appears to be a single layer of polyester insulation - a possible failure mode in the even of excessive operating temperature or tape degredation.

- **Semiconductor ratings** :

Both primary FET's and certain secondary rectifiers are running close to or on the limit of the manufacturers maximum specified operating voltages without room for margin.
In addition it is possible to draw excessive load current and overload the +/-15V rectifiers causing imminent failure of these devices due to overheating.

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APPENDIX A

Fig 1: 5V ripple pk-pk @10A
50mV/5uS. 65-70mV typ. pk @ 66KHz

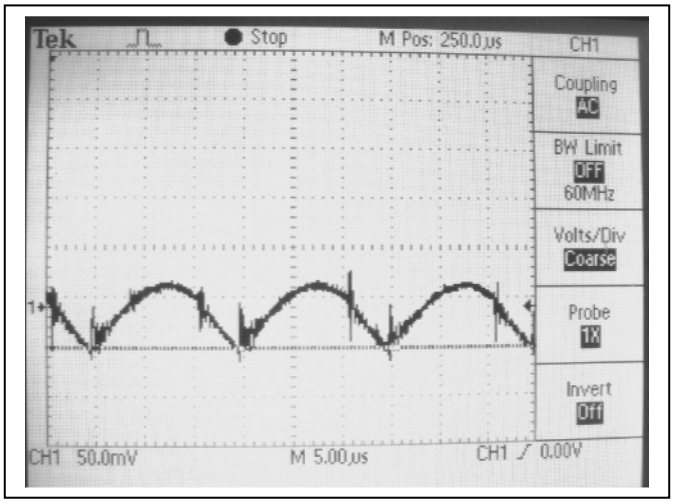

Fig 2: +24V ripple pk-pk @1.6A (5V @ 0A)
10mV/5uS. 20mV typ. @ 66KHz

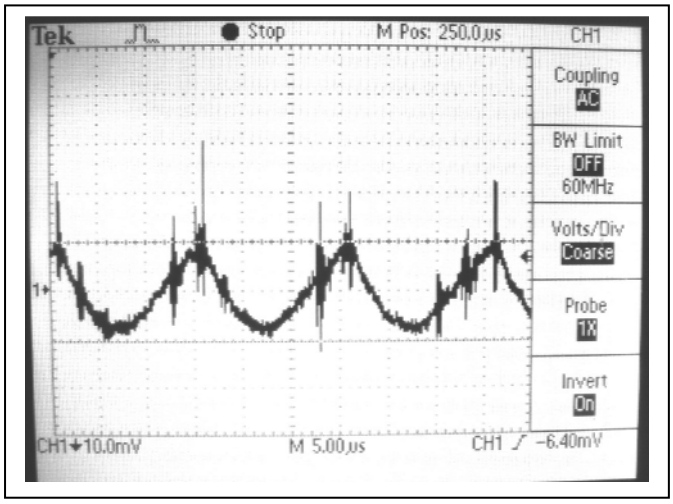

Fig 3: +15V ripple pk-pk @ 0.8A (5V @ 0A)
50mV/5uS. 150mV typ. @ 66KHz

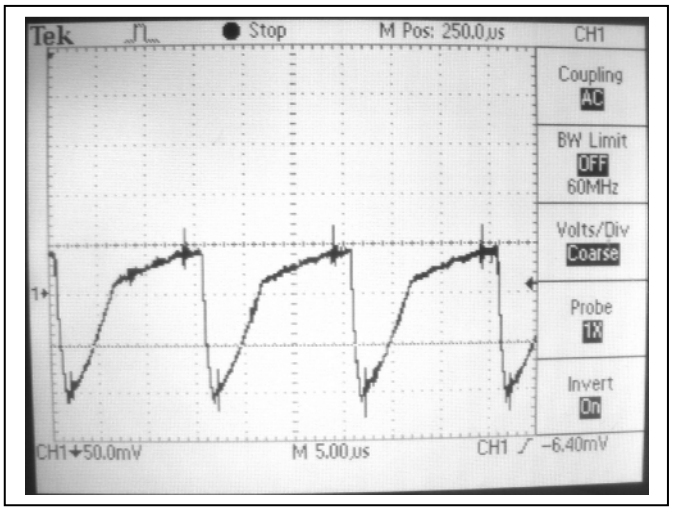

Fig 4: +15V ripple pk-pk @ 0.8A (5V @ 2.5A)
10mV/5uS. 10mV typ. @ 66KHz

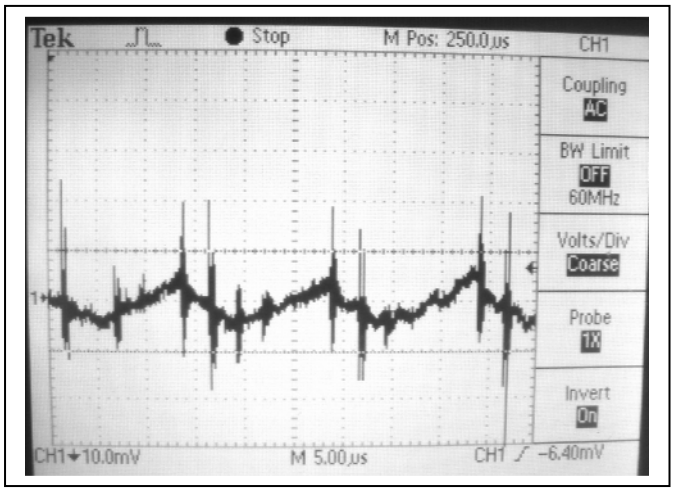

Fig 5: -15V ripple pk-pk @ 0.5A (5V @ 0A)
20mV/5uS. 16mV typ. @ 66KHz

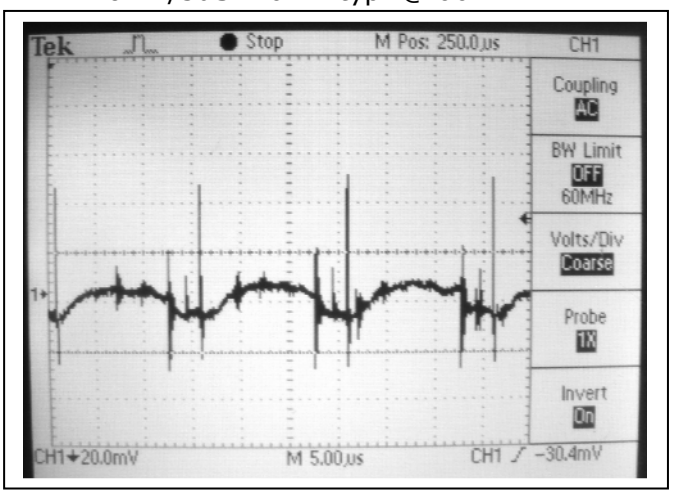

Fig 6: 5V dynamic response 20-100% load 1kHz
Ch1 = 5V output (2V/Div),Ch2 = current (5V=5A)

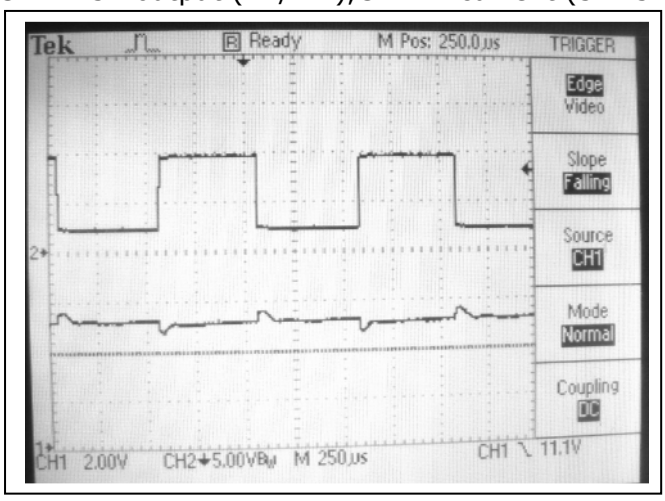

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Fig 7: Q1 (230V) drain voltage (+5 & +15 @ full load)
100V/2.5uS. 500V pk measured. FET 600V rated.

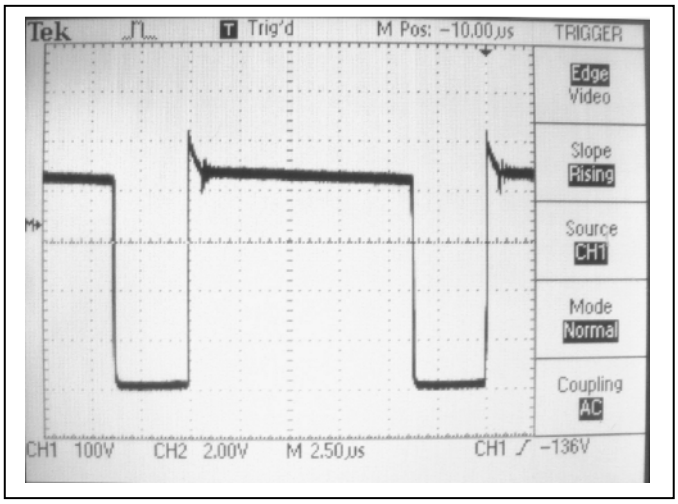

Fig 8: Q8 (230V) drain voltage (+24 & -15 @ full load)
100V/2.5uS. 450V pk measured. FET 600V rated.

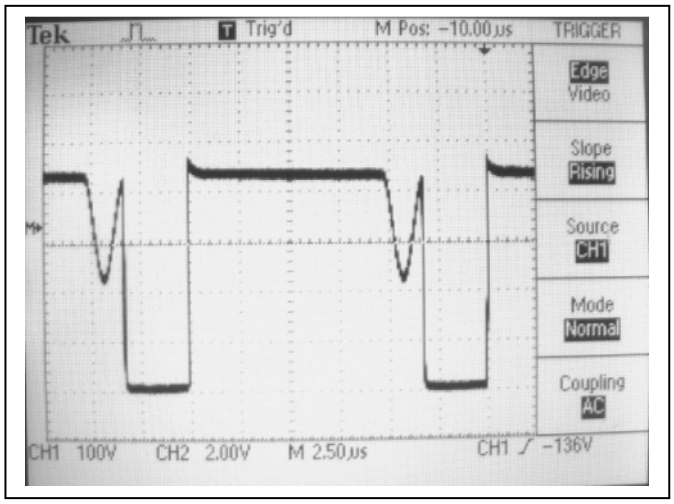

Fig 9: Q1 (230V) source current (+5 ,+15 full load)
50mV = 500mA. 1.8A pk measured.

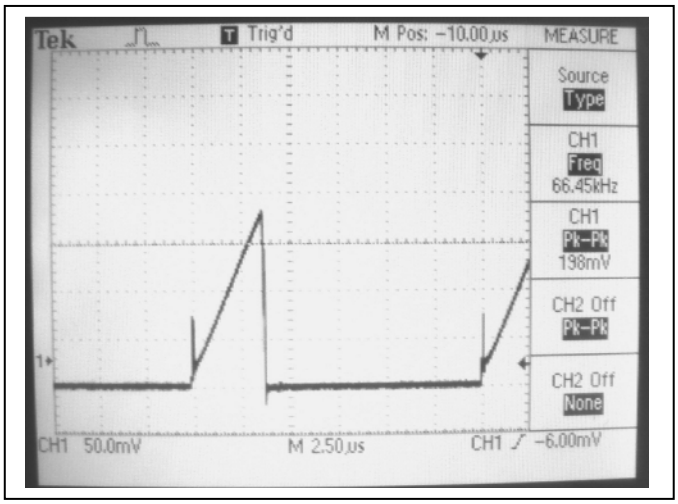

Fig 10: Q8 (230V) source current (+24, -15V full load)
50mV = 500mA. 1.6A pk measured.

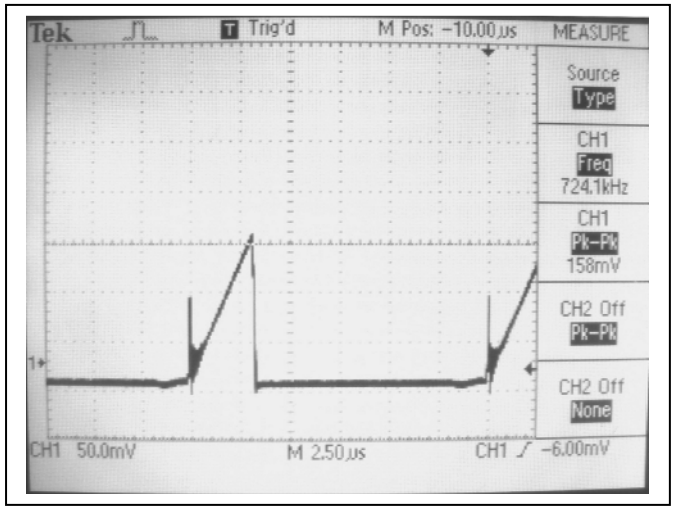

Fig 11: Inrush current @115Vac
10V=10A/1mS. 16A pk measured typ.

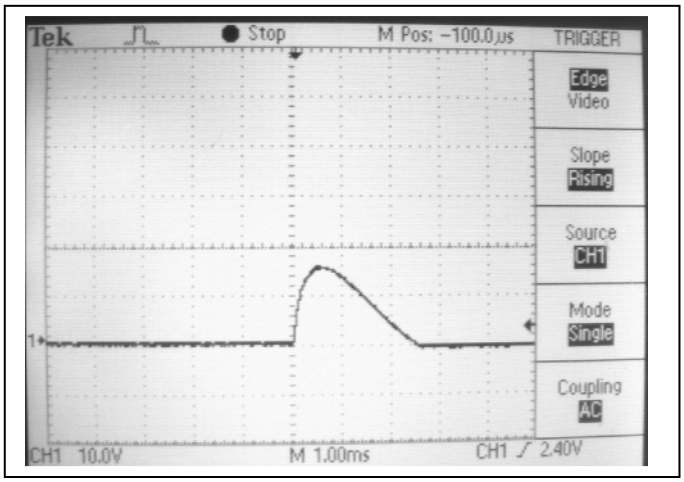

Fig 12: Inrush current @230Vac
10V=10A/1mS. 44A pk measured typ.

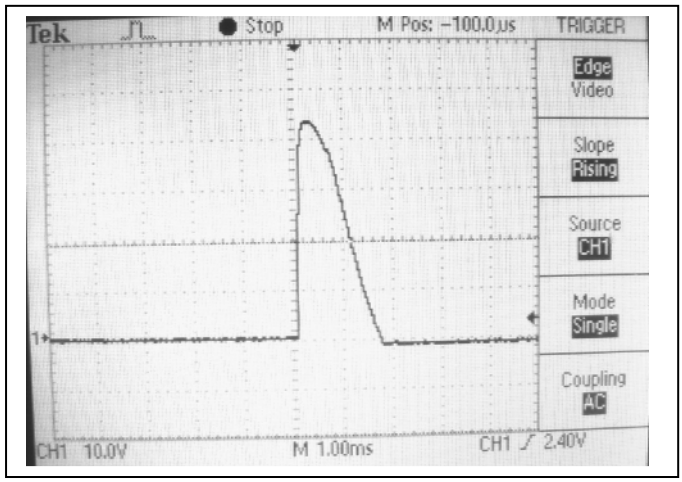

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Fig 13: +5V hold up from 115Vac full load
CH1 = 5V output @ 1V/Div
CH2 = AC mains @ 200V/Div
T = 25mS/Div

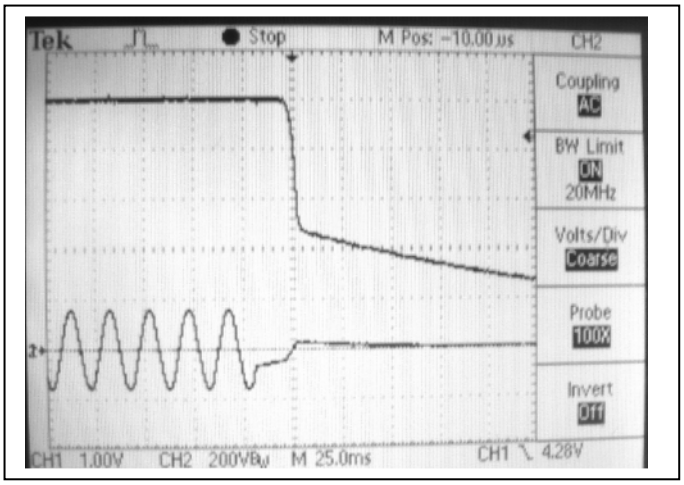


Fig 14: +5V hold up from 230Vac full load
CH1 = 5V output @ 1V/Div
CH2 = AC mains @ 200V/Div
T = 25mS/Div

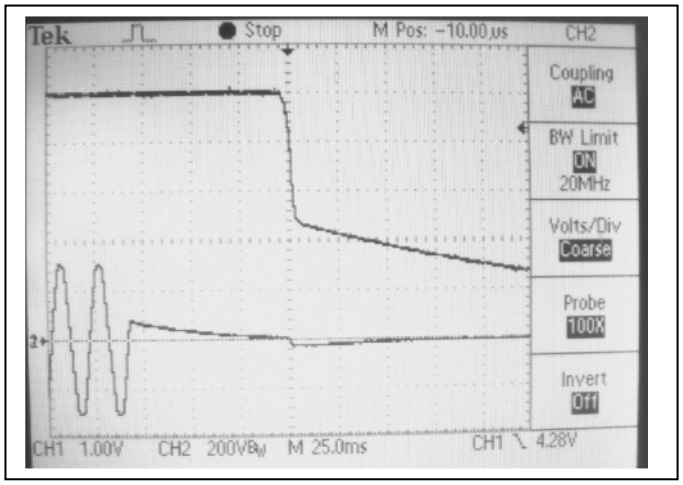
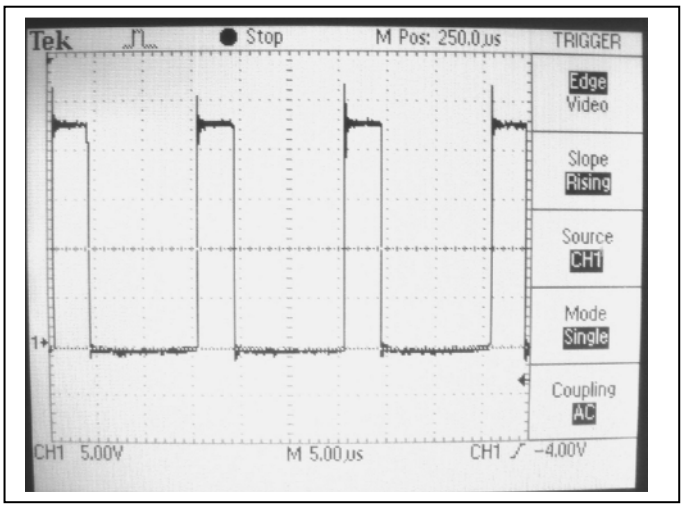


Fig 15: 5V rectifier (STPS3045CT) @ full load (230Vac)
5V/5uS. 25V pk measured. Device rated 45V

Fig 16: +24V rectifier (MURF1620)@ full load (230Vac)
20V/5uS. 96V pk measured. Device rated 200V



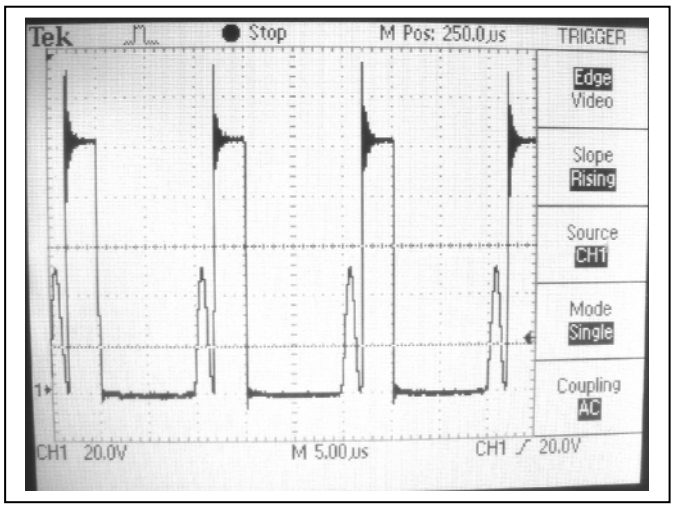
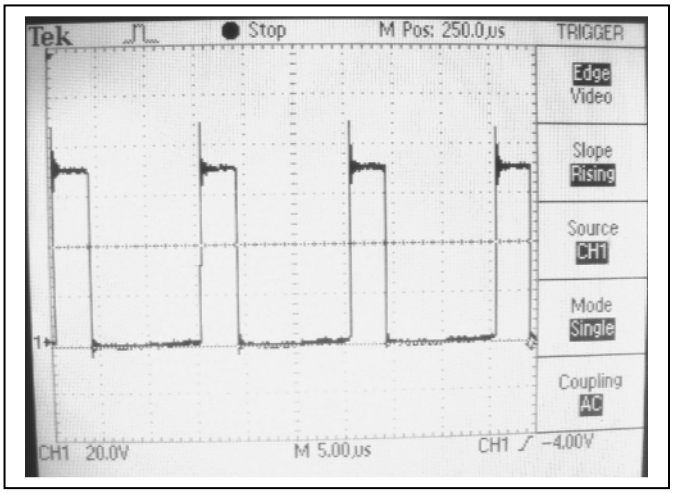


Fig 17: +15V rectifier (MBRS190T3)@ full load (230Vac)
20V/5uS. 88V pk measured. Device rated 90V

Fig 18: -15V rectifier (MBRS190T3) @ full load (230Vac)
20V/5uS. 84V pk measured. Device rated 90V



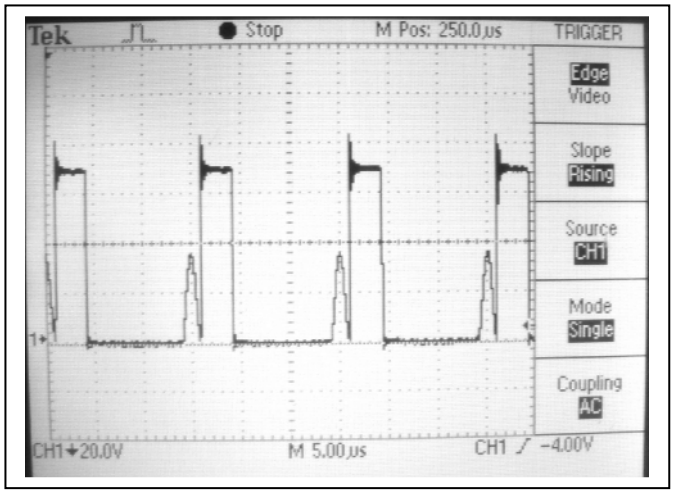


Fig 19: PFC, Input current, power @230Vac
100W output power loading

Fig 20 : PFC, Input current, power @115Vac
100W output power loading

APPENDIX B :- SHORTFORM DATA SHEETS

Q1 & 8 SWITCHING FET'S

International
IOR Rectifier

SMPS MOSFET

PD - 94838

IRFIB6N60APbF

HEXFET® Power MOSFET

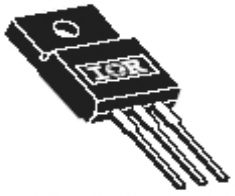
V_{DSS}	Rds(on) max	I_D
600V	0.75Ω	5.5A

Applications

- Switch Mode Power Supply (SMPS)
- Uninterruptable Power Supply
- High speed power switching
- High Voltage Isolation = 2.5KVRMS⑥
- Lead-Free

Benefits

- Low Gate Charge Qg results in Simple Drive Requirement
- Improved Gate, Avalanche and dynamic dv/dt Ruggedness
- Fully Characterized Capacitance and Avalanche Voltage and Current



TO-220 FULLPAK

G D S

Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V	5.5	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V	3.5	
I_{DM}	Pulsed Drain Current ①	37	
P_D @ T_C = 25°C	Power Dissipation	60	W
	Linear Derating Factor	0.48	W/°C
V_{GS}	Gate-to-Source Voltage	± 30	V
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 150	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting torqe, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

Typical SMPS Topologies:

- Single Transistor Forward
- Active Clamped Forward

Notes ① through ⑥ are on page 8

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Power Supply Test Report

5V RECTIFIER

STPS3045CT/CG/CR/CP/CPI/CW/CFP

POWER SCHOTTKY RECTIFIER

MAIN PRODUCT CHARACTERISTICS

$I_{F(AV)}$	2 x 15 A
V_{RRM}	45 V
T_j (max)	175 °C
V_F	0.57 V

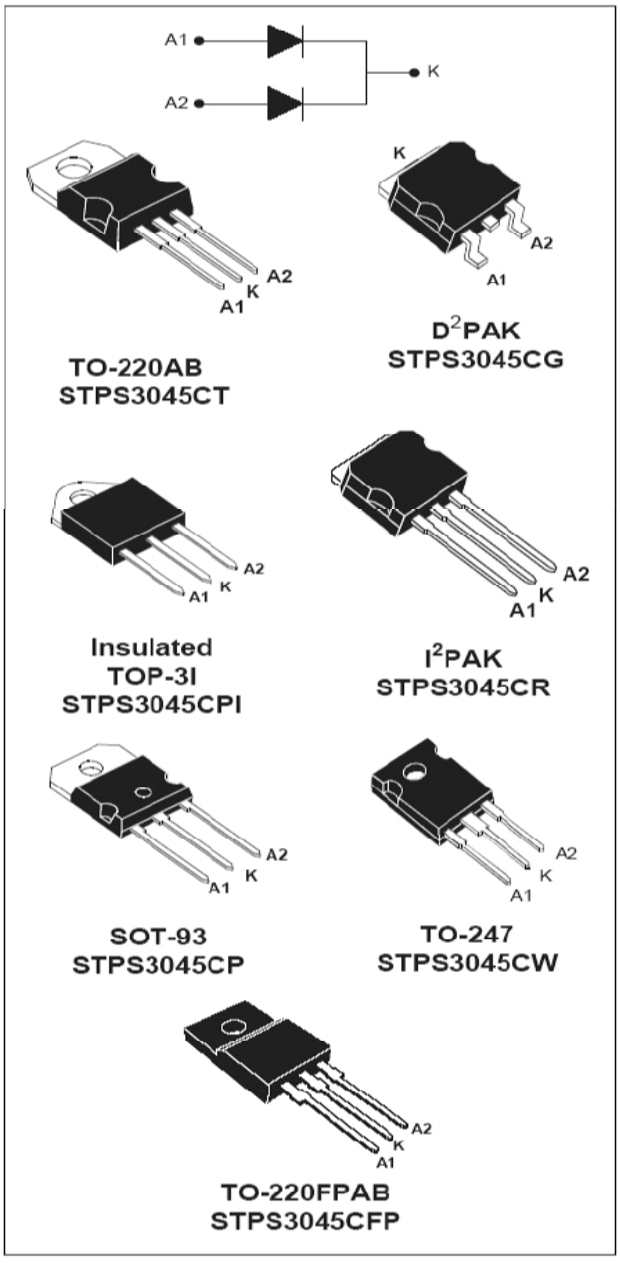
FEATURES AND BENEFITS

- VERY SMALL CONDUCTION LOSSES
- NEGLIGIBLE SWITCHING LOSSES
- EXTREMELY FAST SWITCHING
- LOW THERMAL RESISTANCE
- INSULATED PACKAGE: TOP-3I
  Insulating voltage = 2500V RMS
  Capacitance = 12pF
- AVALANCHE CAPABILITY SPECIFIED

DESCRIPTION

Dual center tap Schottky rectifier suited for SwitchMode Power Supply and high frequency DC to DC converters.

Packaged either in TO-220AB, TO-220FPAB, D^2PAK, I^2PAK, TO-247, SOT93 or TOP-3I, this device is especially intended for use in low voltage, high frequency inverters, free wheeling and polarity protection applications.



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Power Supply Test Report

A1 POWER ENGINEERING

24V RECTIFIER

MURF1620CT

Preferred Device

SWITCHMODE™ Power Rectifier

These state−of−the−art devices are designed for use in switching power supplies, inverters and as free wheeling diodes.

Features

- Ultrafast 35 Nanosecond Recovery Times
- 150°C Operating Junction Temperature
- Epoxy Meets UL 94 V−0 @ 0.125 in
- High Temperature Glass Passivated Junction
- Low Leakage Specified @ 150°C Case Temperature
- Current Derating @ Both Case and Ambient Temperatures
- Electrically Isolated. No Isolation Hardware Required.
- UL Recognized File #E69369 (Note 1)
- Pb−Free Package is Available*

Mechanical Characteristics:

- Case: Epoxy, Molded
- Weight: 1.9 Grams (Approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead Temperature for Soldering Purposes: 260°C Max. for 10 Seconds

MAXIMUM RATINGS (Per Leg)

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	200	V
Average Rectified Forward Current Total Device, (Rated V_R), T_C = 150°C Total Device	$I_{F(AV)}$	 8 16	A
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz), T_C = 150°C	I_{FM}	16	A
Non−repetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	100	A
Operating Junction and Storage Temperature	T_J, T_{stg}	−65 to +150	°C
RMS Isolation Voltage (t = 1 second, R.H. ≤ 30%, T_A = 25°C) (Note 2) Per Figure 3 Per Figure 4 (Note 1) Per Figure 5	V_{iso1} V_{iso2} V_{iso3}	 4500 3500 1500	V

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

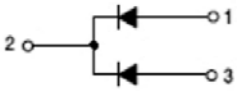
1. UL Recognized mounting method is per Figure 4
2. Proper strike and creepage distance must be provided.

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

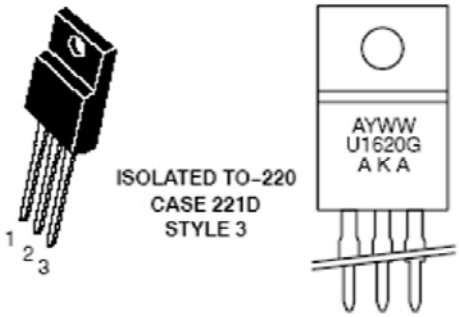
ON Semiconductor®

http://onsemi.com

ULTRAFAST RECTIFIER 16 AMPERES, 200 VOLTS



MARKING DIAGRAM



ISOLATED TO−220
CASE 221D
STYLE 3

A	= Assembly Location
Y	= Year
WW	= Work Week
U1620	= Device Code
G	= Pb−Free Package
AKA	= Diode Polarity

ORDERING INFORMATION

Device	Package	Shipping
MURF1620CT	TO−220	50 Units/Rail
MURF1620CTG	TO−220 (Pb−Free)	50 Units/Rail

Preferred devices are recommended choices for future use and best overall value.

Power Supply Test Report

15V RECTIFIERS

MBRS1100T3, MBRS190T3

Preferred Devices

Schottky Power Rectifier

Surface Mount Power Package

Schottky Power Rectifiers employ the use of the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlay contact. Ideally suited for low voltage, high frequency rectification, or as free wheeling and polarity protection diodes, in surface mount applications where compact size and weight are critical to the system. These state-of-the-art devices have the following features:

Features

- Pb−Free Packages are Available
- Small Compact Surface Mountable Package with J-Bend Leads
- Rectangular Package for Automated Handling
- Highly Stable Oxide Passivated Junction
- High Blocking Voltage − 100 Volts
- 175°C Operating Junction Temperature
- Guardring for Stress Protection

Mechanical Characteristics

- Case: Epoxy, Molded
- Weight: 95 mg (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 260°C Max. for 10 Seconds
- Shipped in 12 mm Tape and Reel, 2500 units per reel
- Cathode Polarity Band

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage MBRS190T3 MBRS1100T3	V_{RRM} V_{RWM} V_R	 90 100	V
Average Rectified Forward Current T_L = 120°C T_L = 100°C	$I_{F(AV)}$	 1.0 2.0	A
Non−Repetitive Peak Surge Current (Surge Applied at Rated Load Conditions Halfwave, Single Phase, 60 Hz)	I_{FSM}	50	A
Operating Junction Temperature (Note 1)	T_J	−65 to +175	°C
Voltage Rate of Change	dv/dt	10	V/ns

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. The heat generated must be less than the thermal conductivity from Junction−to−Ambient: $dP_D/dT_J < 1/R_{\theta JA}$.

ON Semiconductor®

http://onsemi.com

SCHOTTKY BARRIER RECTIFIER 1.0 AMPERE 90, 100 VOLTS

SMB CASE 403A PLASTIC

MARKING DIAGRAM

B1 = Device Code
x = C for MBRS1100T3
9 for MBRS190T3
A = Assembly Location
Y = Year
W = Work Week
▪ = Pb−Free Package

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

Preferred devices are recommended choices for future use and best overall value.

February, 2006 − Rev. 8

Publication Order Number:
MBRS1100T3/D

Power Supply Test Report

A1 POWER ENGINEERING

-15V REGULATOR

National Semiconductor

February 1995

LM2990
Negative Low Dropout Regulator

General Description

The LM2990 is a three-terminal, low dropout, 1 ampere negative voltage regulator available with fixed output voltages of −5, −5.2, −12, and −15V.

The LM2990 uses new circuit design techniques to provide low dropout and low quiescent current. The dropout voltage at 1A load current is typically 0.6V and a guaranteed worst-case maximum of 1V over the entire operating temperature range. The quiescent current is typically 1 mA with 1A load current and an input-output voltage differential greater than 3V. A unique circuit design of the internal bias supply limits the quiescent current to only 9 mA (typical) when the regulator is in the dropout mode ($V_{OUT} - V_{IN} \leq 3V$). Output voltage accuracy is guaranteed to ±5% over load, and temperature extremes.

The LM2990 is short-circuit proof, and thermal shutdown includes hysteresis to enhance the reliability of the device when overloaded for an extended period of time. The LM2990 is available in a 3-lead TO-220 package and is rated for operation over the automotive temperature range of −40°C to +125°C.

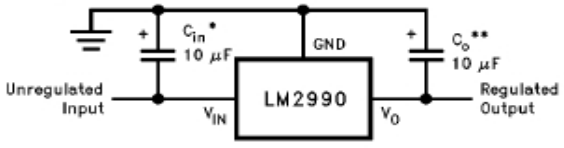
Features

- 5% output accuracy over entire operating range
- Output current in excess of 1A
- Dropout voltage typically 0.6V at 1A load
- Low quiescent current
- Internal short circuit current limit
- Internal thermal shutdown with hysteresis
- Functional complement to the LM2940 series

Applications

- Post switcher regulator
- Local, on-card, regulation
- Battery operated equipment

Typical Application



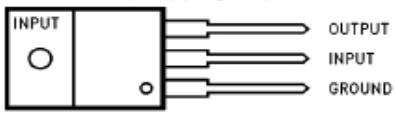
TL/H/10801–1

*Required if the regulator is located further than 6 inches from the power supply filter capacitors. A 1 µF solid tantalum or a 10 µF aluminum electrolytic capacitor is recommended.

**Required for stability. Must be at least a 10 µF aluminum electrolytic or a 1 µF solid tantalum to maintain stability. May be increased without bound to maintain regulation during transients. Locate the capacitor as close as possible to the regulator. The equivalent series resistance (ESR) is critical, and should be less than 10Ω over the same operating temperature range as the regulator.

Connection Diagram and Ordering Information

3-Lead TO-220

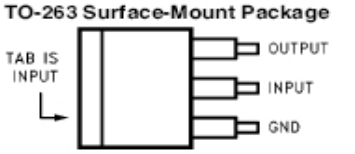


TL/H/10801–2

Front View

Order Number LM2990T-5.0, LM2990T-5.2, LM2990T-12 or LM2990T-15
See NS Package Number T03B

TO-263 Surface-Mount Package



TL/H/10801–11

Top View

TL/H/10801–12

Side View

Order Number LM2990S-5.0,
LM2990S-12 or LM2990S-15
See NS Package Number TS3B

Temperature Range	Output Voltage				Package
	-5.0	-5.2	-12	-15	
−40°C to +125°C	LM2990T-5.0	LM2990T-5.2	LM2990T-12	LM2990T-15	TO-220
	LM2990S-5.0		LM2990S-12	LM2990S-15	TO-263

 TL/H/10801 RRD-B30M75/Printed in U. S. A.

LM2990 Negative Low Dropout Regulator

Power Supply Test Report

A1 POWER ENGINEERING

+15V REGULATOR

National Semiconductor

March 2000

LM2940/LM2940C
1A Low Dropout Regulator

General Description

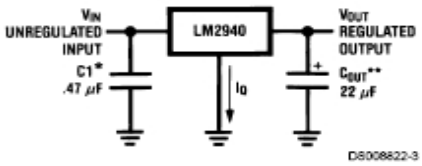
The LM2940/LM2940C positive voltage regulator features the ability to source 1A of output current with a dropout voltage of typically 0.5V and a maximum of 1V over the entire temperature range. Furthermore, a quiescent current reduction circuit has been included which reduces the ground current when the differential between the input voltage and the output voltage exceeds approximately 3V. The quiescent current with 1A of output current and an input-output differential of 5V is therefore only 30 mA. Higher quiescent currents only exist when the regulator is in the dropout mode ($V_{IN} - V_{OUT} \leq 3V$).

Designed also for vehicular applications, the LM2940/LM2940C and all regulated circuitry are protected from reverse battery installations or 2-battery jumps. During line transients, such as load dump when the input voltage can momentarily exceed the specified maximum operating voltage, the regulator will automatically shut down to protect both the internal circuits and the load. The LM2940/LM2940C cannot be harmed by temporary mirror-image insertion. Familiar regulator features such as short circuit and thermal overload protection are also provided.

Features

- Dropout voltage typically 0.5V @I_O = 1A
- Output current in excess of 1A
- Output voltage trimmed before assembly
- Reverse battery protection
- Internal short circuit current limit
- Mirror image insertion protection
- P+ Product Enhancement tested

Typical Application



*Required if regulator is located far from power supply filter.

**C_{OUT} must be at least 22 µF to maintain stability. May be increased without bound to maintain regulation during transients. Locate as close as possible to the regulator. This capacitor must be rated over the same operating temperature range as the regulator and the ESR is critical; see curve.

Ordering Information

Temperature Range	Output Voltage						Package
	5.0	8.0	9.0	10	12	15	
0°C ≤ T_J ≤ 125°C	LM2940CT-5.0		LM2940CT-9.0		LM2940CT-12	LM2940CT-15	TO-220
	LM2940CS-5.0		LM2940CS-9.0		LM2940CS-12	LM2940CS-15	TO-263
−40°C ≤ T_J ≤ 125°C	LM2940T-5.0	LM2940T-8.0	LM2940T-9.0	LM2940T-10	LM2940T-12		TO-220
	LM2940S-5.0	LM2940S-8.0	LM2940S-9.0	LM2940S-10	LM2940S-12		TO-263
−40°C ≤ T_J ≤ 85°C	LM2940IMP-5.0	LM2940IMP-8.0	LM2940IMP-9.0	LM2940IMP-10	LM2940IMP-12	LM2940IMP-15	SOT-223
	LM2940IMPX-5.0	LM2940IMPX-8.0	LM2940IMPX-9.0	LM2940IMPX-10	LM2940IMPX-12	LM2940IMPX-15	SOT-223 in Tape and Reel
SOT-223 Package Marking	L53B	L54B	L0EB	L55B	L56B	L70B	

The physical size of the SOT-223 is too small to contain the full device part number. The package markings indicated are what will appear on the actual device.

Temperature Range	Output Voltage				Package
	5.0	8.0	12	15	
−55°C ≤ T_J ≤ 125°C	LM2940J-5.0/883 5962-8958701EA	LM2940J-8.0/883 5962-9088301QEA	LM2940J-12/883 5962-9088401QEA	LM2940J-15/883 5962-9088501QEA	J16A
	LM2940WG5.0/883 5962-8958701XA				WG16A

For information on military temperature range products, please go to the Mil/Aero Web Site at http://www.national.com/appinfo/milaero/index.html.

 DS008822 www.national.com

LM2940/LM2940C 1A Low Dropout Regulator

Power Supply Test Report

A1 POWER ENGINEERING

OUTPUT CAPACITORS

ALUMINUM ELECTROLYTIC CAPACITORS

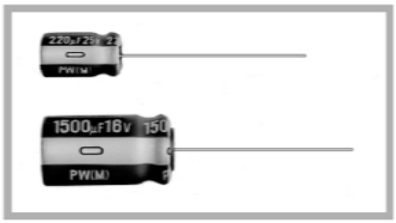
nichicon

PW Miniature Sized, Low Impedance, High Reliability For Switching Power Supplies series

Smaller · Low Impedance · Long Life · Anti-Solvent Feature (Through 100V only)

- Smaller case size and lower impedance than PM series.
- Low impedance and high reliability withstanding 2000 hours to 8000 hours.
- Capacitance ranges available based on the numerical values in E12 series under JIS.
- Adapted to the RoHS directive (2002/95/EC).

PM Smaller
PA Low Impedance PW



■Specifications

Item	Performance Characteristics
Category Temperature Range	−55 ~ +105°C (6.3 ~ 100V), −40 ~ + 105°C (160 ~ 400V), −25 ~ +105°C (450V)
Rated Voltage Range	6.3 ~ 450V
Rated Capacitance Range	0.47 ~ 15000μF
Capacitance Tolerance	±20% at 120Hz, 20°C
Leakage Current	Rated voltage (V): 6.3 ~ 100 / 160 ~ 450 Leakage current: After 1 minute's application of rated voltage, leakage current is not more than 0.03CV or 4 (μA), whichever is greater. / CV ≤ 1000 : I = 0.1CV+40 (μA) max. (1 minute's) CV > 1000 : I = 0.04CV+100 (μA) max. (1 minute's)
tan δ	For capacitance of more than 1000μF, add 0.02 for every increase of 1000μF. Measurement frequency : 120Hz, Temperature : 20°C

Rated voltage (V)	6.3	10	16	25	35	50	63	100	160 ~ 250	315 · 350	400 · 450
tan δ (MAX.)	0.22	0.19	0.16	0.14	0.12	0.10	0.09	0.08	0.15	0.20	0.25

Stability at Low Temperature (120Hz)

Rated voltage (V)		6.3 · 10	16 · 25	35 · 50	63 · 100	160 · 200	250	315 · 350	400	450
Impedance ratio (MAX.)	Z−25°C / Z+20°C	—	—	—	—	3	3	4	6	15
	Z−40°C / Z+20°C	—	—	—	—	4	6	8	10	—
	Z−55°C / Z+20°C	3	3	3	3	—	—	—	—	—

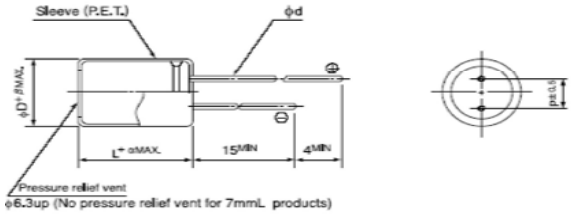
Endurance: After an application of D.C. bias voltage plus the rated ripple current for 8000 hours (2000 hours for D = 4, 5 and 6.3, 3000 hours for D = 8, 5000 hours for D = 10, 7000 hours for D = 12.5) at 105°C the peak voltage shall not exceed the rated D.C.voltage, capacitors meet the characteristic requirements listed at right.

Capacitance change	Within ±20% of initial value
tan δ	200% or less of initial specified value
Leakage current	Initial specified value or less

Shelf Life: After storing the capacitors under no load at 105°C for 1000 hours, and after performing voltage treatment based on JIS C 5101-4 clause 4.1 at 20°C, they will meet the specified value for endurance characteristics listed above.

Marking: Printed with white color letter on dark brown sleeve.

■Radial Lead Type



α	
	(L = 7) 1.0
	(L < 20) 1.5
	(L ≥ 20) 2.0

(mm)

φD	4	5	6.3	8	10	12.5	16	18	20	22	25
P	1.5	2.0	2.5	3.5	5.0	5.0	7.5	7.5	10.0	10.0	12.5
φd	0.45	0.5 (0.45)	0.5 (0.45)	0.6	0.6	0.6 ※0.8	0.8	0.8	1.0	1.0	1.0
β	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0

※ : Applied to L>25 products
( ) : Applied to 7mmL products

• Please refer to page 21 about the end seal configulation.

Type numbering system (Example : 10V 680μF)

1	2	3	4	5	6	7	8	9	10	11	12
U	P	W	1	A	6	8	1	M	P	D	

Size code
Configuration※
Capacitance tolerance (±20%)
Rated Capacitance (680μF)
Rated voltage (10V)
Series name
Type

※ Configuration

φ D	Pb-free leadwire Pb-free PET sleeve
4 · 5	DD
6.3	ED (7mm L : DD)
8 · 10	PD
12.5 ~ 18	HD
20 ~ 25	RD

●Frequency coefficient of rated ripple current

V	Cap. (μF) \ Frequency	50Hz	120Hz	300Hz	1kHz	10kHz ~
6.3 ~ 100	~ 56	0.20	0.30	0.50	0.80	1.00
	68 ~ 330	0.55	0.65	0.75	0.85	1.00
	390 ~ 1000	0.70	0.75	0.80	0.90	1.00
	1200 ~ 15000	0.80	0.85	0.90	0.95	1.00
160 ~ 450	0.47 ~ 220	0.80	1.00	1.25	1.40	1.60
	330 ~ 470	0.90	1.00	1.10	1.13	1.15

Please refer to page 21, 22, 23 about the formed or taped product spec.
Please refer to page 3 for the minimum order quantity.

●Dimension table in next page.

CAT.8100V

APPENDIX C : PRODUCT DATASHEET (DELETED FOR PROTECTION)