

Self-Powered Active Load

1 Introduction

The TBOH02A is a self-powered, precision active load. It is fully analog and does not contain any clocked circuitry.

It was designed for EMC pre-compliance testing and for supply noise measurements of low and medium power DC/DC converters. The active load can be used in EMC test set ups of DC/DC converters without adding any emissions of its own.

The TBOH02A does not need a separate supply voltage and operates as low as 2V. Its features include constant resistance and constant current mode. A 10 turn potentiometer with dial, a range switch and a precision reference enable accurate setting of current or resistance. Furthermore it can be controlled by an external voltage.

As the design is fully analog, supply noise measurements using the TBOH02A as load will not be superimposed with additional noise in contrary to such measurements carried out with digitally controlled active loads.

The TBOH02A can not only be used as active load for power supply measurements, but also as current sink or current source for power LED testing and similar applications. It also comes handy when testing equipment in the field, where no external power is available



The TBSOH02 operates from 2V to 70V. The maximum current is up to 10A, however it has to be taken care that the maximum power without additional cooling is limited to 50W...60W, depending on ambient temperature. The power dissipation should not exceeded a value, where the heat sink temperature crosses 70°C. A fan, attached to the heat sink, can increase the maximum power rating up to 100W.

The design is based on the *EDN, August 2005* article *Precision active load operates as low as 2V* by Joel Setton

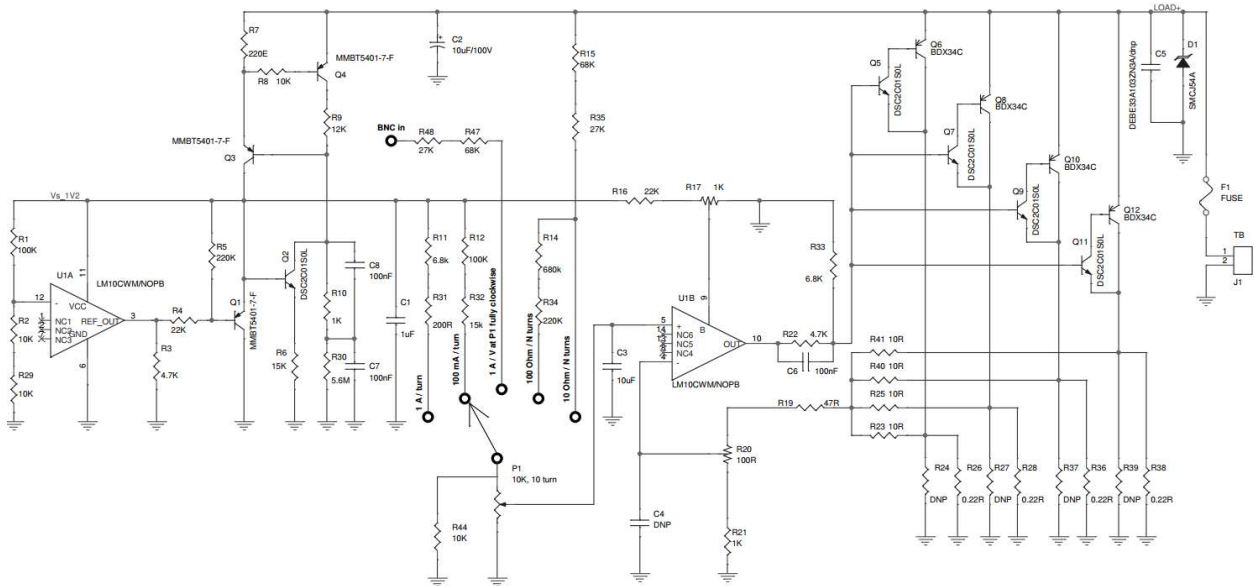
By courtesy of Joel Setton, Crolles, France

2 Parameters

Self-Powered Active Load

- Operating voltage range: 2V – 70V
- Maximum current: 10A, note restriction concerning maximum continuous dissipation
- Minimum current: 2,4mA (self powering current consumption)
- Power rating: max. 25W continuously; with additional fan up to 100W continuously
- Ranges: 0A – 1A, 0A – 10A, 1Ω - 10Ω, 10Ω - 100Ω
- External voltage control input, 1A/V with the potentiometer set fully clockwise
- Reference drift: 0.002%/°C
- Operating temperature range: 0°C – 50°C

3 Schematic



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4 BOM

C1	1uF	CAP CER 1uF 25V 10% X5R 0603	CC0603KRX5R8BB105	YAGEO
C2	10uF	CAP ALUM 10UF 100V 20% RADIAL	UVR2A100MED	Nichicon
C3	10uF	CAP CER 10uF 16V 10% X6S 0805	C2012X6S1C106K	TDK CORPORATION
C6,C7,C8	100nF	CAP CER 0.1UF 100V 10% X7R 0603	GRM188R72A104KA35D	Murata
D1	SMCJ54A	DIODE TVS 54V 1500W UNI 5% SMC	SMCJ54A	Littelfuse Inc
J1	TB	BARRIER TERMINAL BLOCK 2 PIN 10MM	KF-1000	Kaifeng Electronic
J2	B3B-EH-A	CONN HEADER EH TOP 3POS 2.5MM	B3B-EH-A	JST
J3	B6B-EH-A	CONN HEADER EH TOP 6POS 2.5MM	B6B-EH-A	JST
Q1,Q3,Q4	MMBT5401-7-F	TRANS PNP 150V 350MW SMD SOT23-3	MMBT5401-7-F	DIODES INC
Q2,Q5,Q7,Q9,Q11	MMBTA06-7-F	TRANSISTOR NPN 80V SOT23-3	TRANS NPN 100V 0.02A	Panasonic Electronic Components
Q6,Q8,Q10,Q12	BDX34C	TRANSISTOR PNP 100V 10A TO-220	BDX34C	ON Semiconductor
R1,R12,R33	100K	RES 100K OHM 1/10W 1% 0603	AC0603FR-07100KL	YAGEO
R2,R6,R8,R29,R44	10K	RES 10.0K OHM 1/10W 1% 0603 SMD	RC0603FR-0710KL	YAGEO
R32	15k	RES 15K OHM 1/10W 1% 0603 SMD	RC0603FR-0715KL	YAGEO
R3	4.7K	RES 4.7K OHM 1/10W 1% 0603 SMD	RC0603FR-074K7L	YAGEO
R15,R47	68K	RES 68.0K OHM 1/10W 1% 0603 SMD	RC0603FR-0768KL	YAGEO
R5,R34	220K	RES 220K OHM 1/10W 1% 0603 SMD	RC0603FR-07220KL	YAGEO
R7	220E	RES 220 OHM 1/10W 1% 0603 SMD	RC0603FR-07220RL	YAGEO
R9	12K	RES 12.0K OHM 1/10W 1% 0603 SMD	RC0603FR-0712KL	YAGEO
R30	5.6M	RES 5.6M OHM 1/10W 5% 0603 SMD	RC0603JR-075M6L	YAGEO
R11	6.8k	RES 6.80k OHM 1/10w 1% 0603 SMD	RC0603FR-076K8L	YAGEO
R14	680k	RES 680k OHM 1/10w 1% 0603 SMD	RC0603FR-07680KL	YAGEO
R4,R16	22K	RES 22.0K OHM 1/10W 1% 0603 SMD	RC0603FR-0722KL	YAGEO
R17	1K	TRIMMER 1K OHM 0.5W PC PIN	3362P-1-102LF	Bourns Inc.
R19	47R	RES 47.0 OHM 1/10W 1% 0603 SMD	RC0603FR-0747RL	YAGEO
R20	100R	TRIMMER 100 OHM 0.5W PC PIN	3362P-1-101LF	Bourns Inc.
R10,R21,R22	1K	RES 1.00K OHM 1/10W 1% 0603 SMD	RC0603FR-071KL	YAGEO
R23,R25,R40,R41	10R	RES 10.0 OHM 1/10W 1% 0603 SMD	RC0603FR-0710RL	YAGEO
R26,R28,R36,R38	0.22R	RES .25 OHM 5W 5% CERAMIC WW	CB5JBR250-ND	Stackpole Electronics Inc
R31	200R	RES 200 OHM 1/10W 1% 0603 SMD	RC0603FR-07200RL	YAGEO
R35,R48	27K	RES 27K OHM 1/10W 1% 0603 SMD	RC0603FR-0727KL	YAGEO
U1	LM10CWM/NOPB	IC OPAMP GP 14SOIC	LM10CWM/NOPB	Texas Instruments
P1	3590S-2-103L	POT 10K OHM 7/8" RD WW	3590S-2-103L	Bourns Inc.

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Scale Dial	2696	DIAL-7/8" 10-TURN 1/4" SHAFT	2696	TT Electronics
2 pcs Banana Jacks	6883	DUAL BINDING POSTS	6883	Pomona
Fuse Holder	BK/HTB-22I-R	FUSE HLDR CART 250V 10A PNL MNT	BK/HTB-22I-R	Eaton Bussmann
Fuse	BK/ABC-10-R	FUSE CERM 10A 250VAC 125VDC 3AB	BK/ABC-10-R	Eaton Bussmann
BNC Jack	227755-1	CONN BNC JACK STR 50 OHM SOLDER	227755-1	TE Connectivity
Rotary Switch Knob	PKES90B1/4	SWITCH KNOB FLUTED 1.01" W/SKIR	PKES90B1/4	TE Connectivity
Rotary Switch	2P5T	Rotary Switch 2Pole 5 Position	2P5T	HIWOR
Housing	08-8	Plastic Housing	08-8	Changhe Enclosures
Heatsink	YUD-168	Heatsink, L=145mm	YUD-168	TIANJIN R-SWITCH
9 pcs Crimp Contacts	SEH-001T-P0.6	CONN TERM CRIMP EH 22-30AWG mm	SEH-001T-P0.6	JST
Cable Housing	EHR-6	CONN HOUSING EH 6POS 2.5MM CRIMP	EHR-6	JST
Cable Housing	EHR-3	CONN HOUSING EH 3POS 2.5MM CRIMP	EHR-3	JST
4 pcs Thermal Pads	173-9-230P	THERMAL PAD .009" GRAY TO-220	173-9-230P	Wakefield Vette
PCB1	FZTBOH2M	Mainboard PCB	FZTBOH2M	Tekbox
PCB2	FZTBOH2F	Frontpanel PCB	FZTBOH2F	Tekbox
PCB3	FZTBOH2R	Rotary Switch PCB	FZTBOH2R	Tekbox

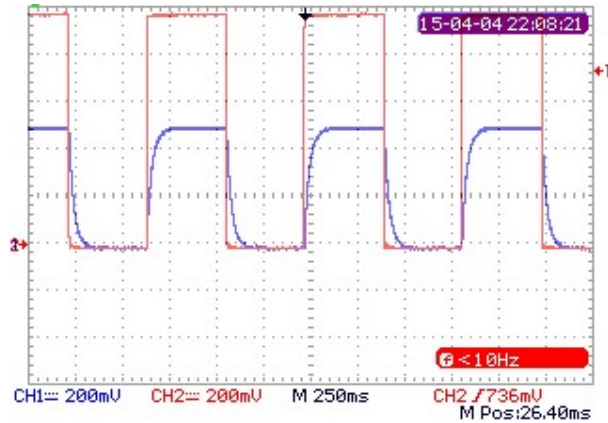
5 Calibration

Set the rotary switch to the 100mA/turn range and set the dial of P1 to 1 turn. Then adjust R17 to 100mA load current. Then turn P1 fully clockwise and adjust R20 to 1A load current. Repeat this two adjustments in sequence, because they interact slightly.

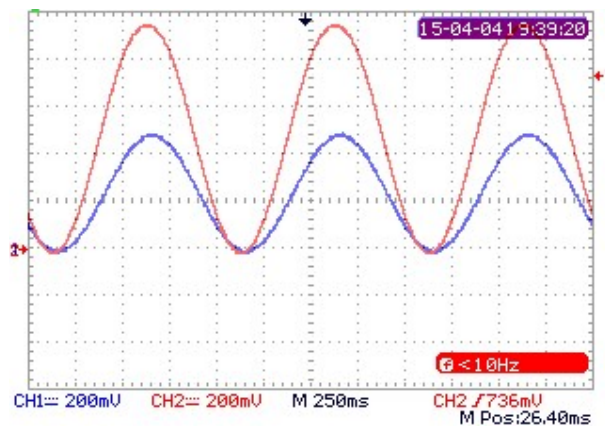
Self-Powered Active Load

6 Voltage control

Set the rotary switch into V.C. position. With the multi-turn potentiometer set fully clockwise, 1V at the external voltage control input translates into a load current of 1A. Similarly, setting the multi turn potentiometer into 500mA position (5 turns) would result in 500mA/V.



Square control signal; P1 set to 500mA/V; red: signal at V.C. input; blue: load current, 1mA/mV



Sinusoidal control signal; P1 set to 500mA/V; red: signal at V.C. input; blue: load current, 1mA/mV

If a higher slew rate of the load current is required, the value of C3 can be reduced.

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7 Current / power rating

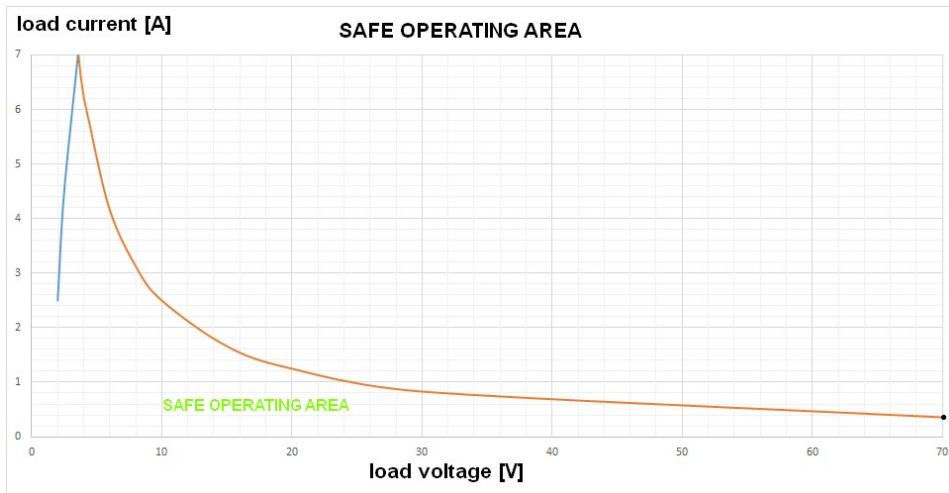
The maximum current rating of the active load is 10A. It has to be taken into account however that the continuous power without additional cooling shall not exceed 25W at room temperature. Furthermore, due to the relation of collector current and collector-emitter voltage, the maximum current at low voltages is limited:

Maximum current at 2V: 2,5A

Maximum current at 2,5V: 4,5A

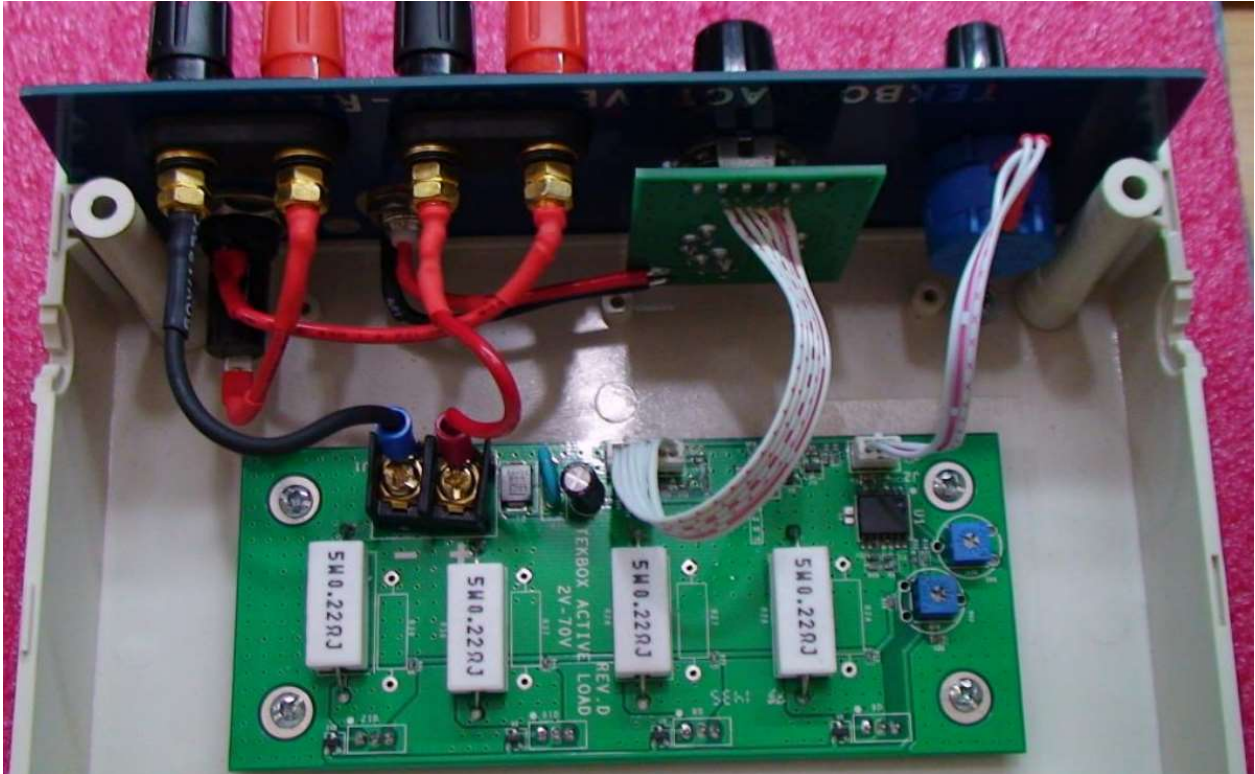
The load voltage should be $> 4V$ for load currents of 10A

Safe operating area at room temperature, without additional cooling:



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8 Assembly



9 History

Version	Date	Author	Changes
V1.0	05.09.2014	L.D.HIEU	Creation of the document
V1.1	15.05.2020	Mayerhofer	Upgrade to TBOH02A with larger heat sink
V1.2	29.05.2020	Mayerhofer	Add new picture

Table 1 – History