A MAINS-ZERO TRIAC-TRIGGERING CIRCUIT

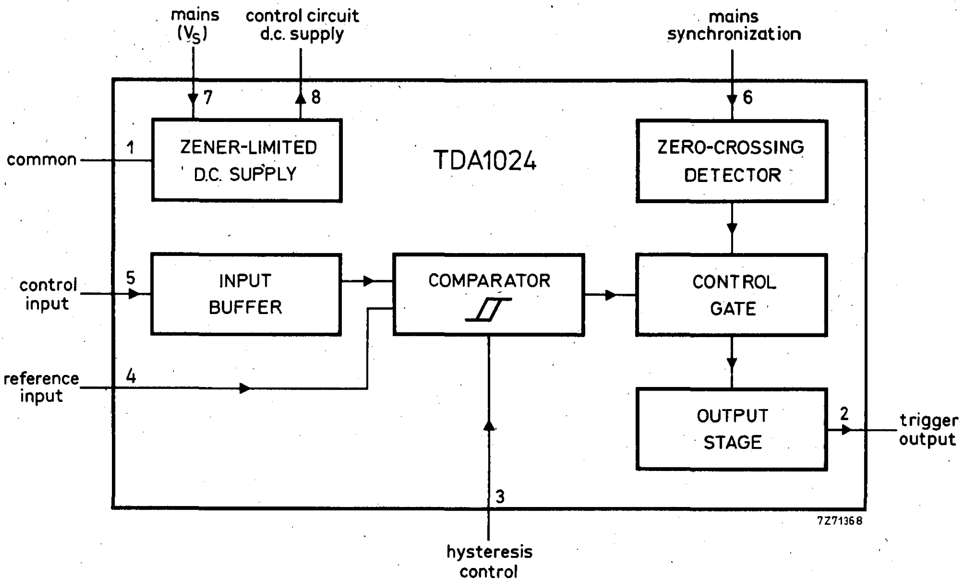
The TDA1024 is a monolithic integrated circuit intended for use in ON/OFF control of triacs in static switching applications. It incorporates zero voltage point triggering to minimize radio interference.
The TDA1024 is mainly intended for applications such as switching resistive loads and replacing mechanical thermostats in, for example:

- central heating installations,
- washing machine heaters,
- water heaters,
- smoothing irons.

QUICK REFERENCE DATA				
Supply voltage (via dropping resistor)	V_S	mains voltage		
Average supply current	$I_{7(av)}$	typ.	10	mA
Trigger pulse width	t_p	typ.	195	µs
Max. trigger current capability	I_{2max}	>	100	mA

PACKAGE OUTLINE plastic 8 lead dual in-line (see general section).

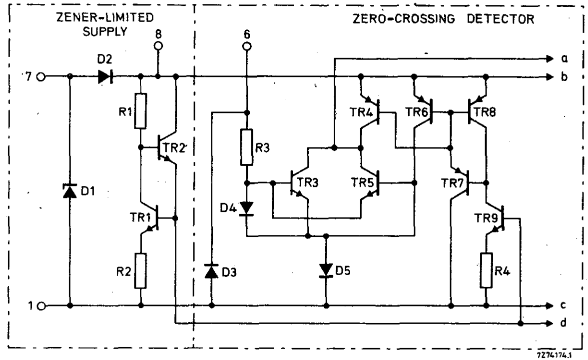
BLOCK DIAGRAM

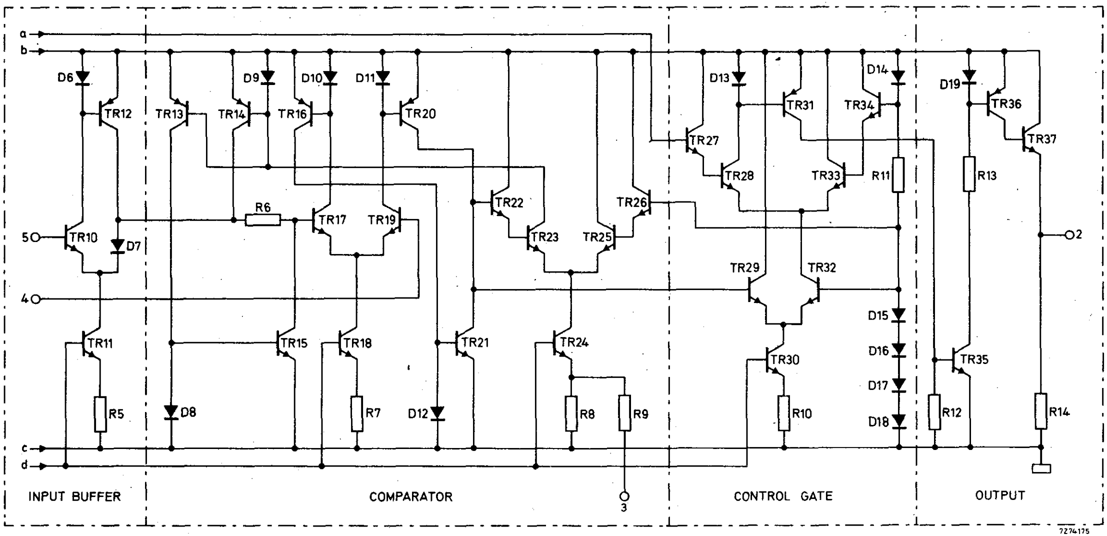


Functions of the TDA1024 are :

- a comparator with Schmitt-trigger action.
  This circuit compares the control voltage at pin 5 with the reference voltage at pin 4 and switches on when the control voltage exceeds the reference voltage. The hysteresis of the circuit is adjustable between 20 mV and 300 mV by selection of the value of a resistor connected between pin 3 and pin 1.
- an input buffer circuit with high input impedance and low output impedance. This circuit presents a low impedance to the comparator input so that the hysteresis of the circuit is independent of variations of the input voltage.
- a control circuit d.c. supply which provides a zener-limited nominal 6,5 V supply, at a current of up to 30 mA, for application to the input bridge.
- a zero-crossing detector which produces an output when the sinusoidal voltage applied to pin 6 passes through zero; advantage of this mode is minimum radio interference.
- a control gate which inhibits the output trigger pulse from the TDA1024 unless there are outputs from both zero-crossing detector and comparator.
- an output stage which delivers a positive-going, mains-synchronized triac trigger pulse whenever the control gate is activated. The output from this stage is current-limited and protected against short-circuit. Since the current and voltage in the load must be in phase for mains-synchronized switching, the applications of the TDA1024 are restricted to the switching of resistive loads.

CIRCUIT DIAGRAM





RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Supply voltage (pin 7)	V_S	max.	8	V
Voltage on pins 2, 3, 4, 5 and 8	V_{2-1}; V_{3-1}; V_{4-1}; V_{5-1}; V_{8-1}	max.	8	V

Currents

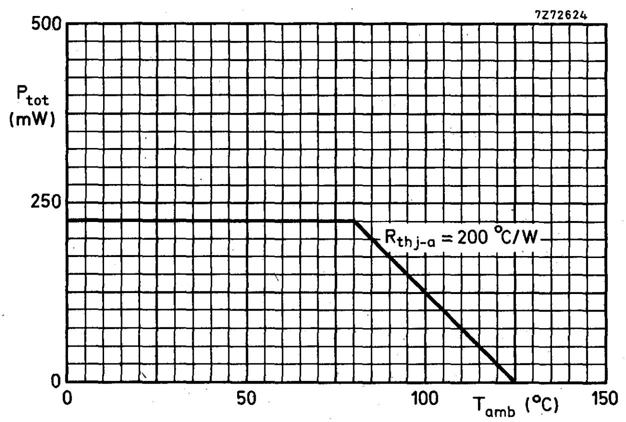
Supply current (pin 7); average value	$\pm I_{7(av)}$	max.	30	mA
peak value	$\pm I_{7M}$	max.	80	mA
Current at pins 4, 5, and 6	I_4; I_5; $\pm I_6$	max.	10	mA
Non-repetitive peak current at pin 7 (t_p<50μs)	$\pm I_{7SM}$	max.	2	A
Output current (pin 2); average value	$I_{2(av)}$	max.	30	mA
peak value (t_p<300 μs)	I_{2M}	max.	400	mA

Temperatures

Storage temperature	T_{stg}	-55 to + 125	°C
Operating ambient temperature	T_{amb}	-20 to +80	°C

Power dissipation

Total power dissipation — see derating curve below

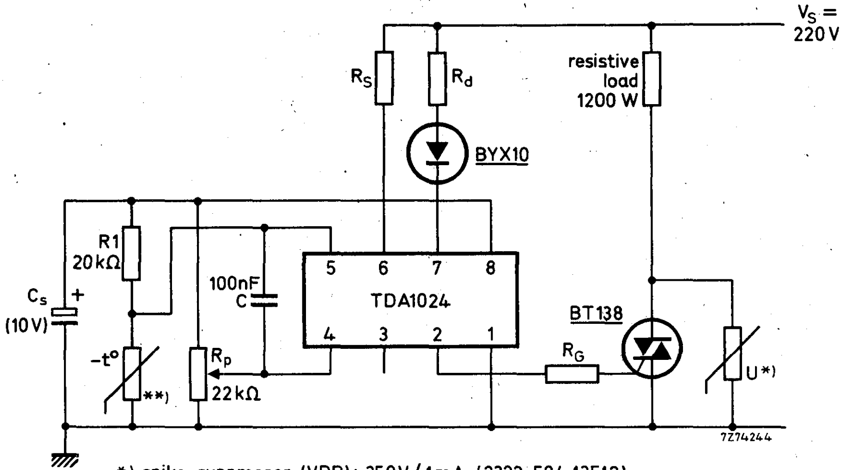


CHARACTERISTICS at T_{amb} = 25 °C; f = 50 Hz

Zero-crossing detector				
Trigger pulse width at $I_{6(rms)}$ = 1 mA; V_{8-1} = 5,5 V	t_p	typ.	195	μs
			130 to 265	μs
Synchronization resistor	see Fig. 3			
Trigger output (pin 2)				
Max. current capability at V_{8-1} = 5,5 V	$-I_{2\,max}$	>	100	mA
Trigger current capability	see Figures 5, 6, 7 and 8			
Max. trigger voltage at $-I_2$ = 100 mA	V_{2-1}	>	4	V
Gate resistor	see Fig. 4			
Comparator at V_{8-1} = 6,5 V				
Hysteresis; pin 3 not connected; I_3 = 0	ΔV_{5-4}		10 to 30	mV
Hysteresis; pin 3 connected to common; V_3 = 0	ΔV_{5-4}	typ.	300	mV
Input current at $V_{4-1} > V_{5-1}$ (pin 4)	I_4	<	5	μA
Input current (pin 5)	I_5	<	5	μA
Control circuit d.c. supply (pin 8)				
Voltage on pin 8 at $I_{7(av)}$ = 10 mA	V_{8-1}	typ.	6,5	V
			5,5 to 7,5	V
IC current consumption (with min. hysteresis) pins 2 and 3 not connected; $V_{5-1} > V_{4-1}$; V_{8-1} = 5,5 V	I_{IC}	<	1,8	mA
IC current consumption (with max. hysteresis) pin 2 not connected; pin 3 connected to common; $V_{5-1} > V_{4-1}$; V_{8-1} = 5,5 V	I_{IC}	<	3	mA
Total average current consumption (pin 7)	see Fig. 9			
Mains dropping resistor	see Figures 10 and 11			
Mains dropping capacitor	see Fig. 12			

APPLICATION INFORMATION

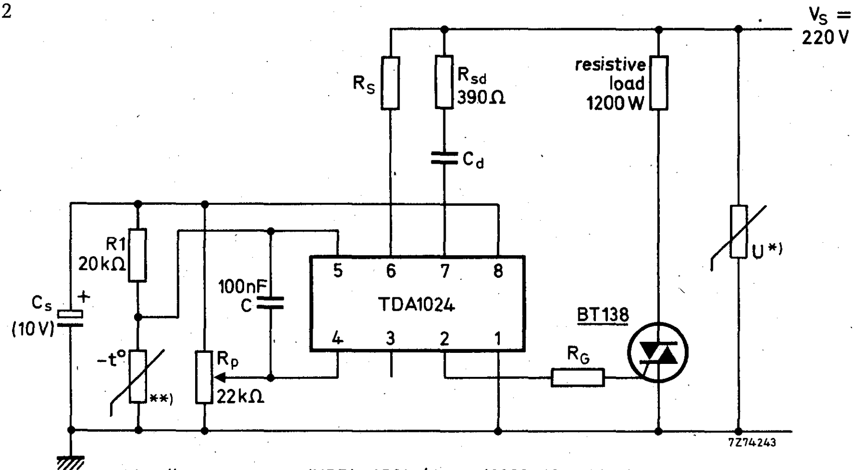
Fig. 1



*) spike suppressor (VDR): 350 V/1 mA (2322 594 13512)
**) $R_{25} = 22\,k\Omega$

The TDA1024 used in a 1200 W thermostat covering the temperature range 5°C to 30°C and designed to minimize the power dissipated by mains dropping resistor R_d by using a rectifier diode.

Fig. 2



*) spike suppressor (VDR): 350 V/1 mA (2322 594 13512)
**) $R_{25} = 22\,k\Omega$

The TDA1024 used in a 1200W thermostat covering the temperature range 5°C to 30°C and designed to minimize the dissipation in the mains voltage reduction circuit by using capacitor C_d.

APPLICATION INFORMATION (continued)

Design data for the two previous circuits (for other circuits the same sequence of component value selection must be used):

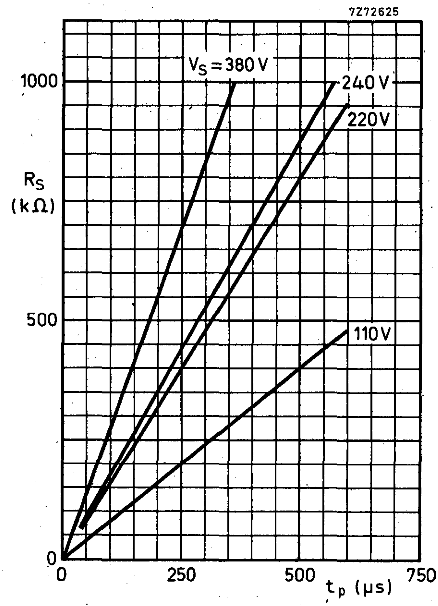
BT138 triac with: V_{GT} = 1,6V at 0 °C
I_{GT} = 72 mA at 0 °C
I_L < 60 mA

Mains voltage: V_S = 220 V
Triac load: 1200 W

Component values and circuit parameters:

parameter		Value Fig. 1	Value Fig. 2	Figure
trigger pulse width	: t_p (μs)	105	105	*)
sync. resistor	: R_S (kΩ)	180	180	3
gate resistor	: R_G (Ω)	33	33	4
average gate current	: $I_{2(av)}$ (mA)	3, 7	3, 7	6
min. required supply current	: I_7 (mA)	6, 5	6, 5	9
mains dropping resistor	: R_d (kΩ)	10	–	10
smoothing capacitor	: C_s (μF)	470	470	10
power dissipated by R_d	: P_{Rd} (W)	3, 2	–	11
mains dropping capacitor	: C_d (nF)	–	270	12
power dissipated by R_{sd}	: P_{Rsd} (mW)	–	190	12

*) See BT138 data sheet.



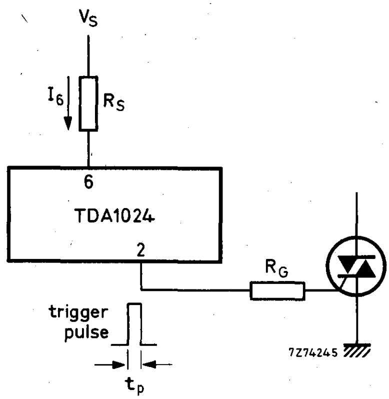
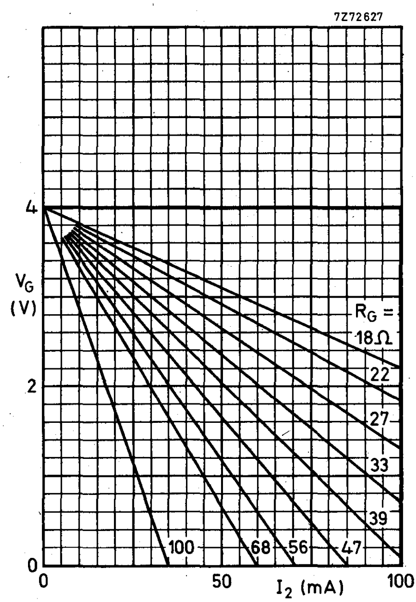


Fig. 3. Synchronization resistor (R_S) value as a function of required trigger pulse width (t_p) with applied mains voltage (V_S) as a parameter.
Tolerance for R_S : ± 5%
for V_S : ± 10%



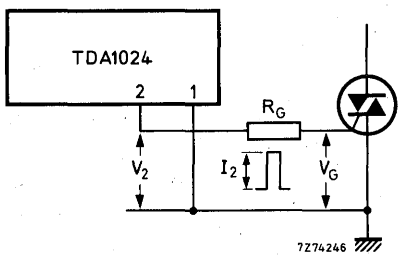
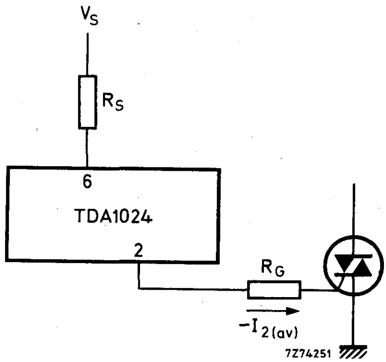


Fig. 4. Gate voltage (V_G) as a function of trigger current (I_2) with gate resistor (R_G) load lines.

Figures 5, 6, 7 and 8, on the next two pages, have to be used with the circuit below. They show the maximum average trigger current $I_{2(av)}$ as a function of the value of R_G with the value of R_S as a parameter for V_S = 110V; 220 V; 240 V; 380 V respectively.



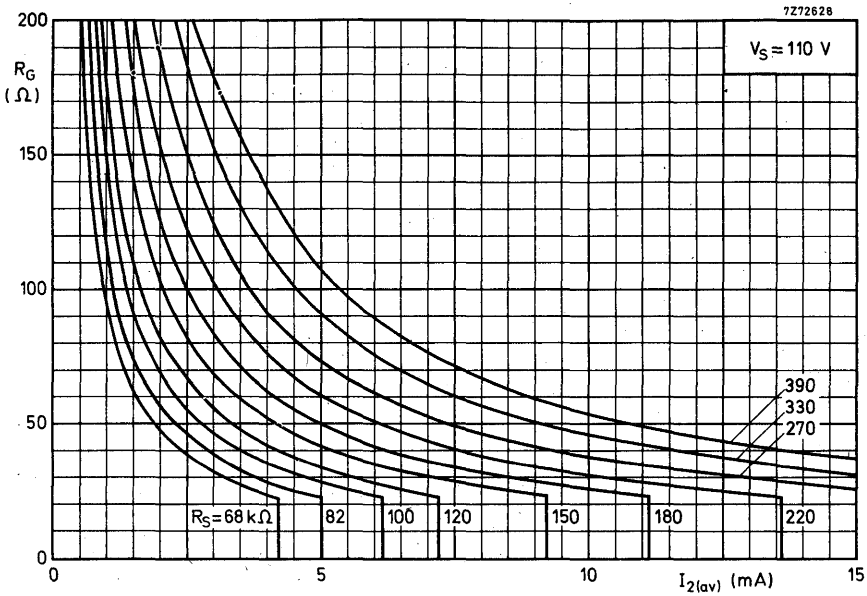

7Z72628
$V_S = 110$ V
R_G (Ω)
200
150
100
50
0
390
330
270
$R_S = 68$ kΩ
82
100
120
150
180
220
0
5
10
15
$I_{2(av)}$ (mA)

Fig. 5

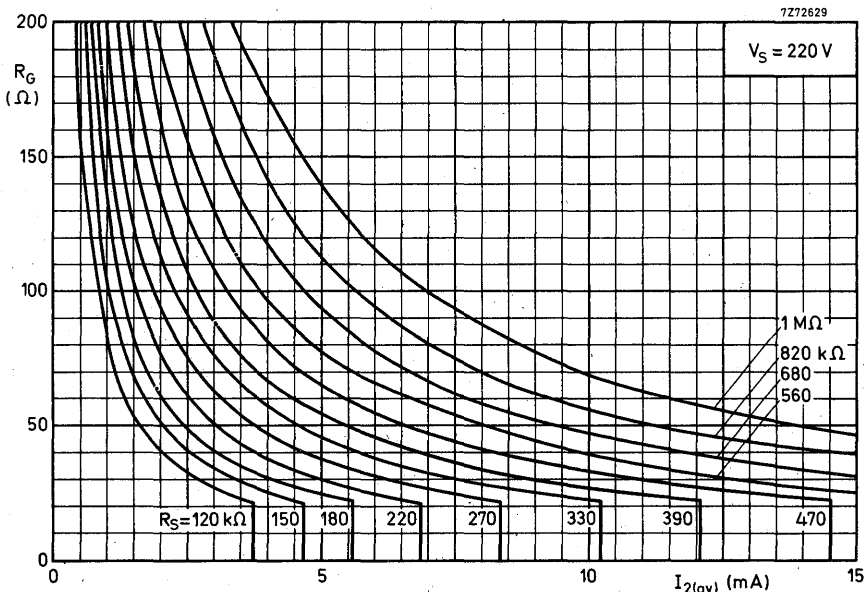

7Z72629
$V_S = 220$ V
R_G (Ω)
200
150
100
50
0
1 MΩ
820 kΩ
680
560
$R_S = 120$ kΩ
150
180
220
270
330
390
470
0
5
10
15
$I_{2(av)}$ (mA)

Fig. 6

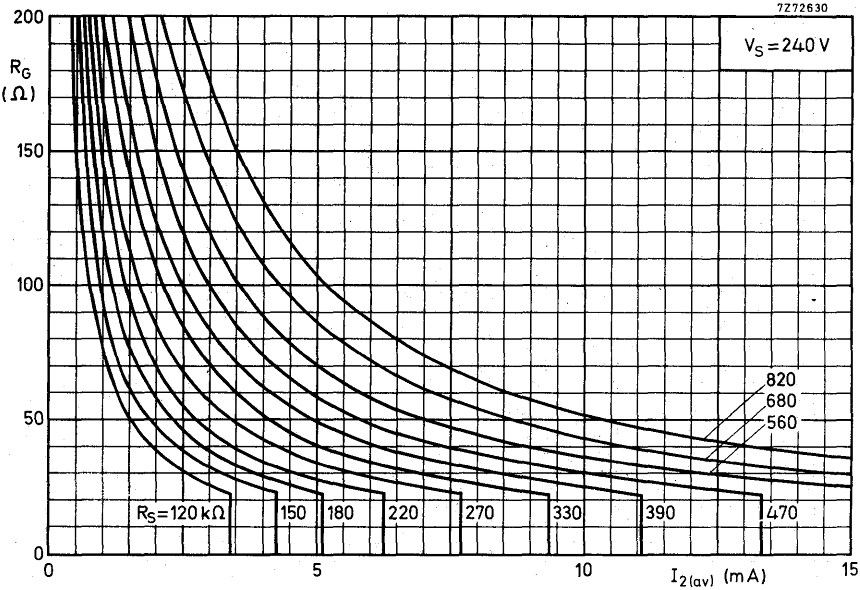

7Z72630
200
150
100
50
0
R_G
(Ω)
$V_S = 240$ V
820
680
560
$R_S = 120$ kΩ
150
180
220
270
330
390
470
0
5
10
15
$I_{2(av)}$ (mA)

Fig. 7

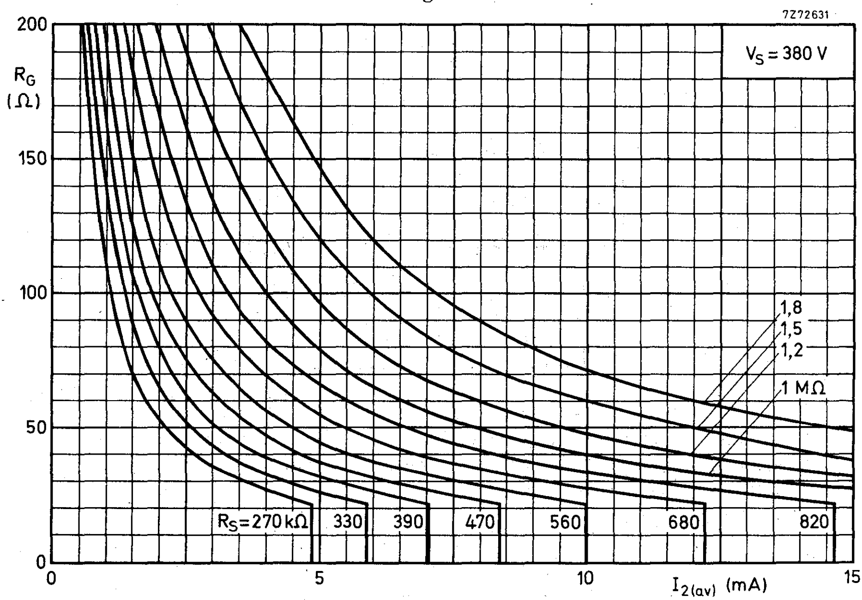

7Z72631
200
150
100
50
0
R_G
(Ω)
$V_S = 380$ V
1,8
1,5
1,2
1 MΩ
$R_S = 270$ kΩ
330
390
470
560
680
820
0
5
10
15
$I_{2(av)}$ (mA)

Fig. 8

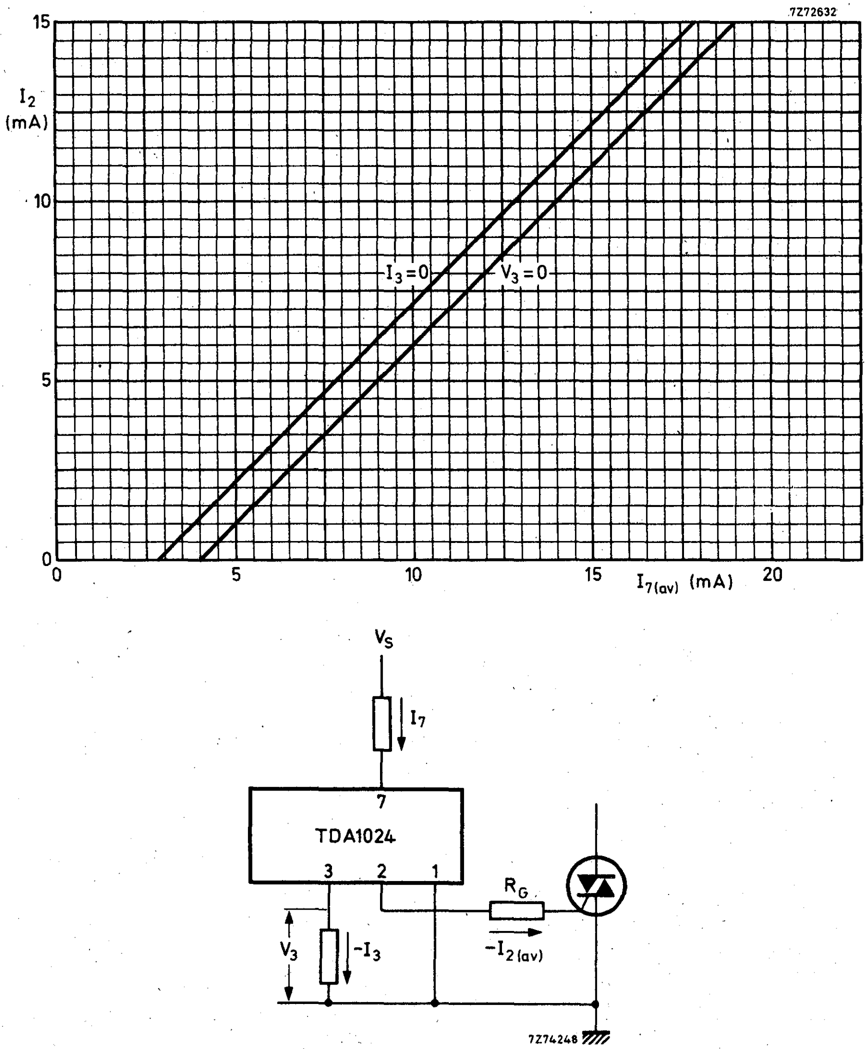
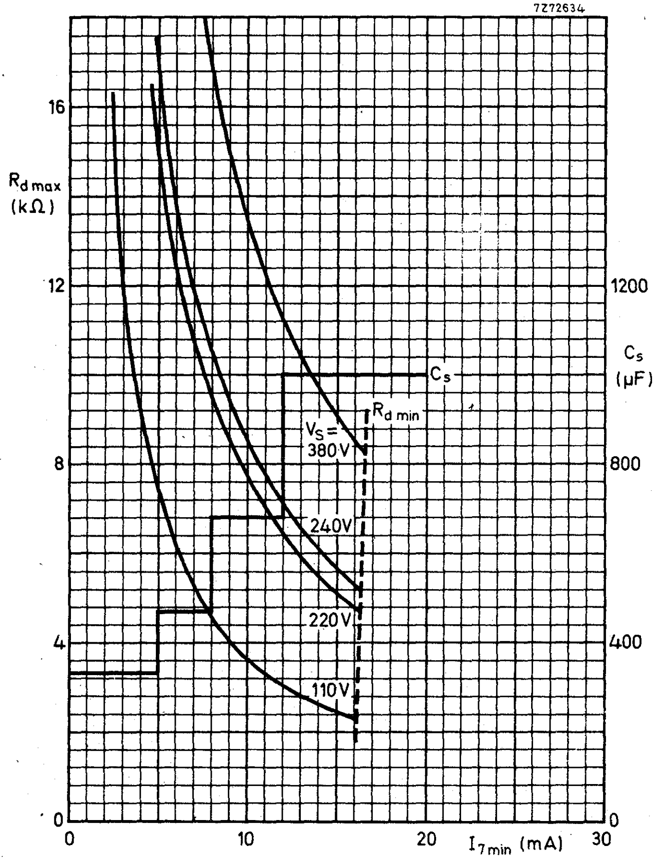


Fig. 9. Minimum required supply current (I_7) as a function of maximum average trigger current ($I_{2(av)}$), with hysteresis setting as a parameter.
$I_3 = 0$; min. hysteresis.
$V_3 = 0$; max. hysteresis.



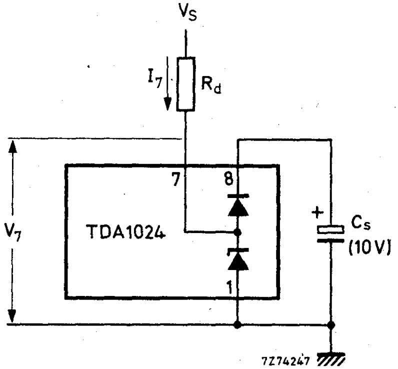
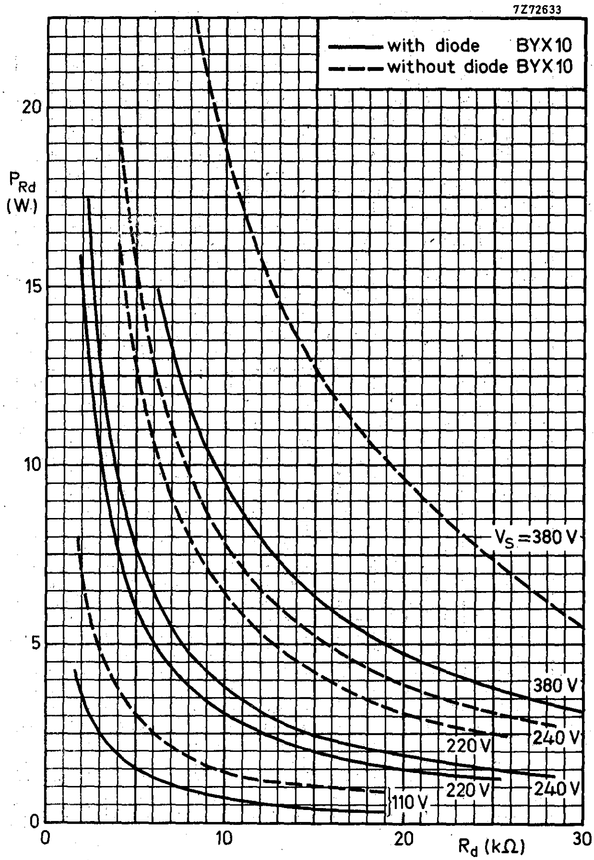


Fig. 10. Value of $R_{d\,max}$ as a function of I_{7min} with supply voltage (V_S) as a parameter.
Also shown is the value of the smoothing capacitor (C_S) as a function of I_{7min}.



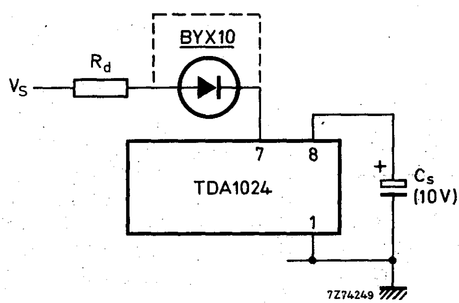
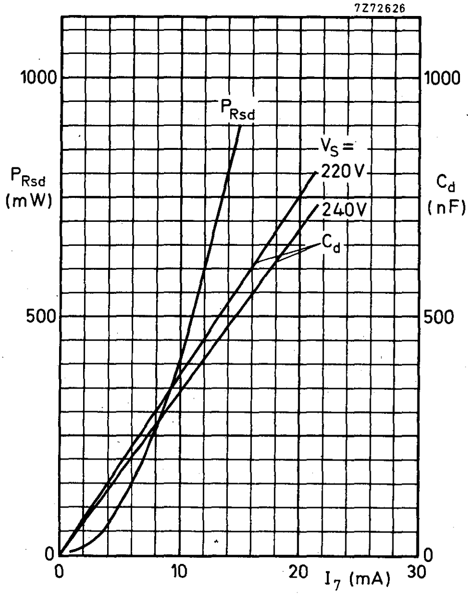


Fig. 11. The power dissipated by mains dropping resistor R_d (P_{Rd}) as a function of its value with the supply voltage (V_S) as a parameter.



Using a capacitor for mains supply voltage dropping.

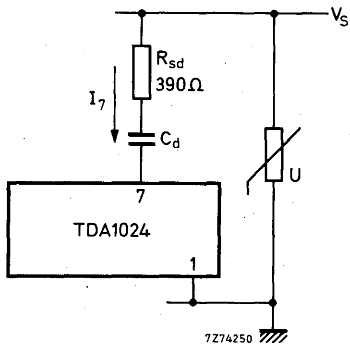


Fig. 12. Power dissipated by the dropping resistor (P_{Rsd}) and the dropping capacitor value (C_d) as a function of the current into pin 7 (I_7) with the mains supply voltage (V_S) as a parameter.