

## Simple Phase Control Circuit

### Description

Integrated circuit, TEA1007, is designed as a general phase control circuit in bipolar technology. It has an internal supply voltage limitation. With typical 150 mA ignition pulse, it is possible to determine the phase-shift

of the ignition point by comparing the mains sync. ramp voltage with a preset required value. It generates a single ignition pulse per half wave; therefore, it is suitable for capacitive and inductive loads in low cost applications.

### Features

- Current consumption  $\leq 2.5$  mA
  - Ignition pulse typ. 150 mA
  - Voltage and current synchronization
  - Internal supply voltage control
- Package:** DIP8

### Block Diagram

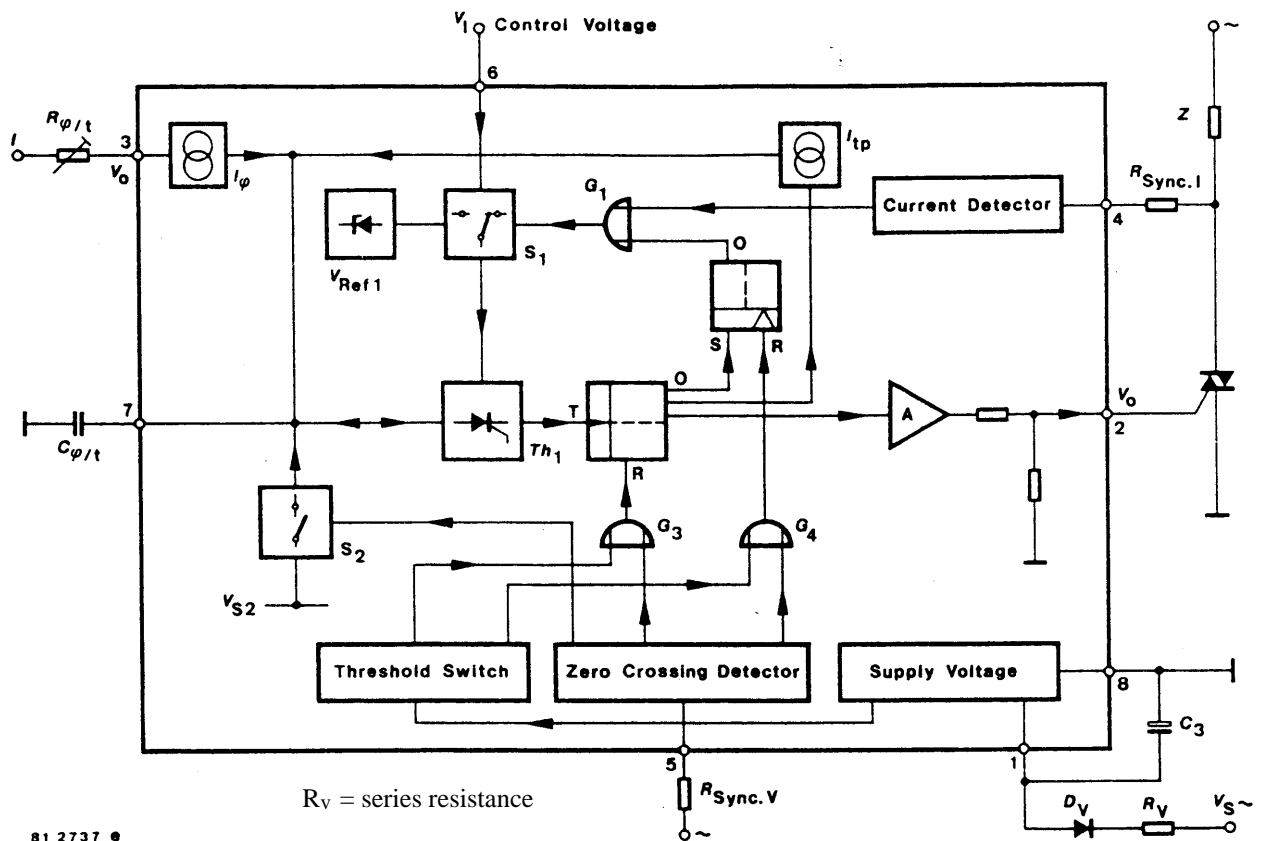


Figure 1. Block diagram with typical circuitry

## General Description

The phase-shift of the ignition point is determined in the usual manner by comparison between a mains synchronized ramp voltage and a predetermined required value. The capacitor  $C_{\varphi/t}$  between Pin 7 and the common reference point Pin 8 is discharged at the zero transition of the mains voltage via the  $V_o$  detector, gate  $G_2$  and switch  $S_2$ . After the end of the zero transition pulse,  $C_{\varphi/t}$  is charged from the constant current source  $I_{\varphi}$ , whose value is adjusted externally with  $R_{\varphi}$  at Pin 3 due to the unavoidable tolerance of  $C_{\varphi/t}$  (Phase 1).

When the potential at Pin 7 reaches the nominal value predetermined at Pin 6, the thyristor  $Th_1$ , which also functions as a comparator, ignites and sets the following clock flip-flop. The output of the clock flip-flop releases the output amplifier, connects a second constant current source to the capacitor  $C_{\varphi/t}$ , and switches the reference voltage switch  $S_1$  to an internally generated threshold voltage  $V_{Ref1}$  via an RS flip-flop and the OR gate  $G_1$ .

The capacitor  $C_{\varphi/t}$  is charged in this second phase by  $I_{\varphi} + I_{tp}$  until it reaches the internal reference voltage  $V_{Ref}$ . The length of this Phase 2 corresponds to the width of the output pulse  $t_p$ . When the capacitor voltage reaches the value  $V_{Ref}$ , thyristor  $Th_1$  ignites again and resets the clock flip-flop to its initial state. The output pulse is thus terminated and the constant source  $I_{tp}$  is switched off. However, the RS flip-flop holds the switch  $S_1$  so that the internal reference voltage remains connected to  $Th_1$ . As  $V_{Ref}$  is greater than the maximum permissible control voltage at Pin 6, this prevents more than one ignition pulse from being generated in each half-cycle of the mains voltage. This is particularly important because the energy contents of the output pulse is of the same order as the internal requirements of the circuit for each half-wave.

In the following zero transition of the mains voltage, the zero transition detector (Input Pin 5) resets the RS flip-flop, discharges  $C_{\varphi/t}$  again via  $S_2$ , and also insures that the clock flip-flop is in the reset condition. A further part of the basic function is the current detector with its input at Pin 4. When controlling inductive loads, the load current lags behind the mains voltage which means that the circuit could generate an ignition pulse during the period in which current is still flowing with a polarity opposite to that of the mains voltage if the current were not taken into account (see figure 2).

This, in turn, would lead, to so-called "gaps" in the load current as the next ignition pulse is generated in the subsequent half-cycle.

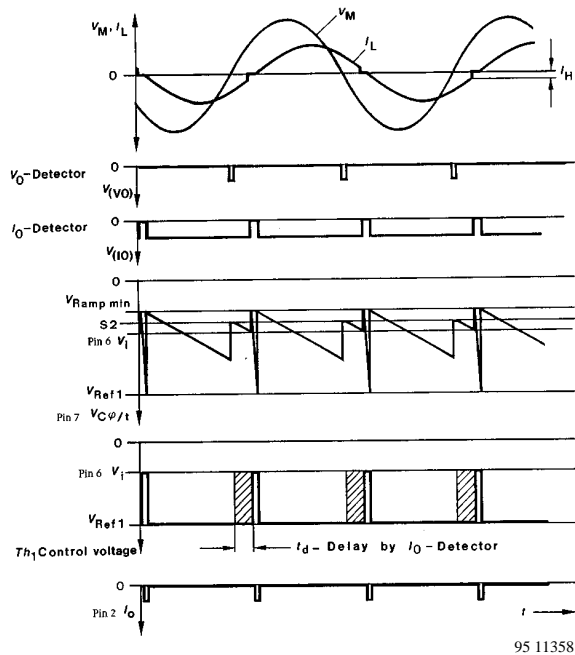


Figure 2. Functional diagram for inductive load of  $\alpha_{max}$

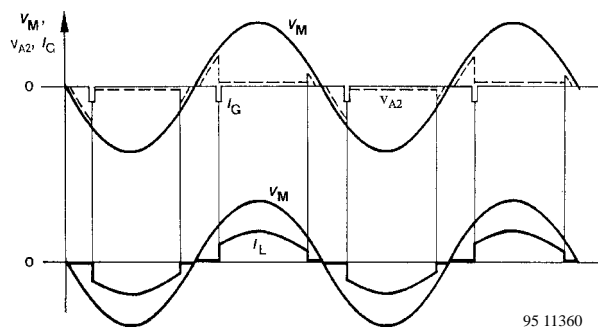


Figure 3. Triac voltages + currents at resistive load

- $V_o$  = Zero cross voltage
- $I_o$  = Zero cross current
- $V_M$  = Mains voltage
- $I_L$  = Load current
- $I_G$  = Gate current
- $V_{HI}$  = Triac voltage at anode HI

In indication as to whether load current is flowing or not is provided by the triac itself. When the triac is ignited, the voltage at electrode H<sub>1</sub> drops from the instantaneous value of the mains voltage to approximately 1.5 V, the value of the forward voltage of the triac. When the load current drops below the hold current of the triac towards the end of the half-cycle, V<sub>H1</sub> again returns to the instantaneous value of the mains voltage. The current detector with its input at Pin 4 now controls this triac voltage and blocks the pulse generator via G<sub>1</sub> and S<sub>1</sub> by increasing the reference voltage as long as the triac is conducting. As, in the case of a resistive load, the triac may be extinguished shortly before the zero transition of the mains voltage – when the load current drops below the hold current – the RS flip-flop must prevent any possible second ignition pulse from being generated.

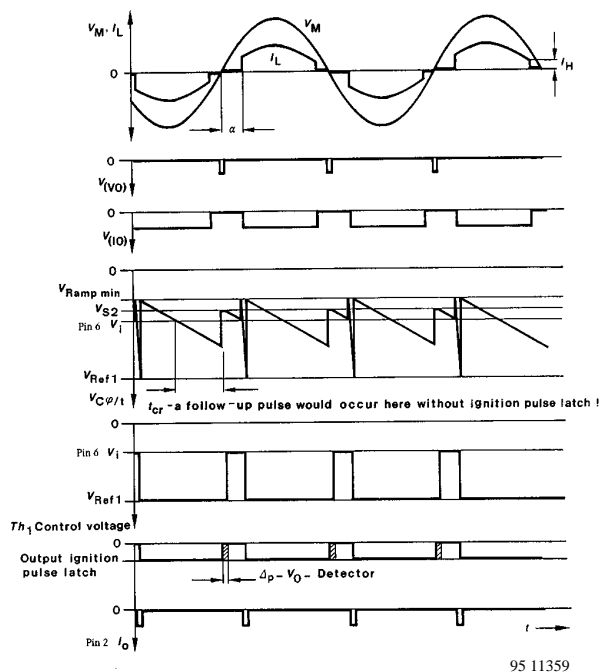


Figure 4. Functional diagram for resistive load and  $\alpha_{\min}$

## Additional Function

An internal supply voltage control circuit insures that output pulses can be generated only when the supply voltage required for operation of all logic functions is available.

Series resistance R<sub>1</sub> can be calculated approx. as follows:

$$R_{1 \max} = 0.85 \frac{V_{M \min} - V_{S \max}}{2 \times I_{\text{tot}}}$$

$I_{\text{tot}} = I_S + I_P + I_X$  whereas

$I_{\text{tot}}$  = Total current consumption

$I_S$  = Current requirement of the IC

$I_P$  = Average current requirement of the triggering pulses

$I_X$  = Current requirement of other peripheral components

## Determination of Gate Series Resistance, Firing Current and Pulse Width

Firing current requirement depends upon the triac used which can be regulated with series resistance as given below:

$$R_{G \max} \approx \frac{12.5 \text{ V} - V_{G \max}}{I_{G \max}} - 110 \Omega$$

$$I_P = \frac{I_G}{T} \times t_p$$

$$t_p \approx \frac{8 \mu\text{s}}{\text{nF}} \times C_\phi$$

whereas:

$V_G$  = Triac's gate voltage

$I_G$  = Triac's gate current

$I_P$  = Gate current requirement – average

$T$  = Period duration of mains frequency

$t_p$  = (firing) pulse width

$C_\phi$  = Ramp capacitor

## Absolute Maximum Ratings

Reference point Pin 8

Parameters	Symbol	Value	Unit
Current consumption Pin 1 $t < 10$ ms	$-I_S$	30	mA
	$-i_s$	60	
Sync. currents: Pin 4 Pin 5 $t < 10$ ms Pin 4 Pin 5	$I_{syncI}$	10	mA
	$I_{syncV}$	10	
	$\pm i_{sync.I}$	60	
	$\pm i_{sync.V}$	60	
Input current Pin 3	$-I_I$	5	mA
Input voltages: Pin 6 Pin 2	$-V_I$	$\cong V_S$	V
	$V_I$	$-V_S \cong V_I \cong 2$	
Power dissipation $T_{amb} = 45^\circ\text{C}$ $T_{amb} = 85^\circ\text{C}$	$P_{tot}$	400	mW
		225	
Junction temperature	$T_j$	125	$^\circ\text{C}$
Ambient temperature range	$T_{amb}$	0 to 80	$^\circ\text{C}$
Storage temperature range	$T_{stg}$	-40 to +125	$^\circ\text{C}$

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient DIP8 SO8 (P.C.) SO8 (ceramic)	$R_{thJA}$	200	K/W
		220	
		140	

## Electrical Characteristics

Reference point Pin 8, unless otherwise specified

Parameters	Test Conditions / Pin	Symbol	Min	Type	Max	Unit
Mains supply	Pin 1	$-V_S$	13.5		17	V
Current consumption		$I_S$			2.5	mA
Sync. currents	Pin 4	$I_{syncI}$		0.35		mA
	Pin 5	$I_{syncV}$		0.65		mA
Output pulse current	$V_S = 13.5$ V, $R_G = 0$ , $V_G = 1.2$ V Pin 2		$I_O$	90	180	mA
Output pulse width	Pin 2 $C_{\varphi/t} = 3.3$ nF $C_{\varphi/t} = 6.8$ nF	$t_p$	8		30	$\mu\text{s}$
		$t_p$	15		64	
Charge current	"Phase 1" Pin 7 $C_{\varphi/t} = 3.3$ nF $C_{\varphi/t} = 6.8$ nF	$I_\varphi$	1		20	$\mu\text{A}$
			2			
	"Phase 2" Pin 7	$I_t$		1.3		mA
Drive current Pin 6		$I_i$			0.5	$\mu\text{A}$
Balance between two half cycles	$V_6 = \text{constant}$	$\Delta\varphi$			$\pm 3$	$^\circ$

**Applications**

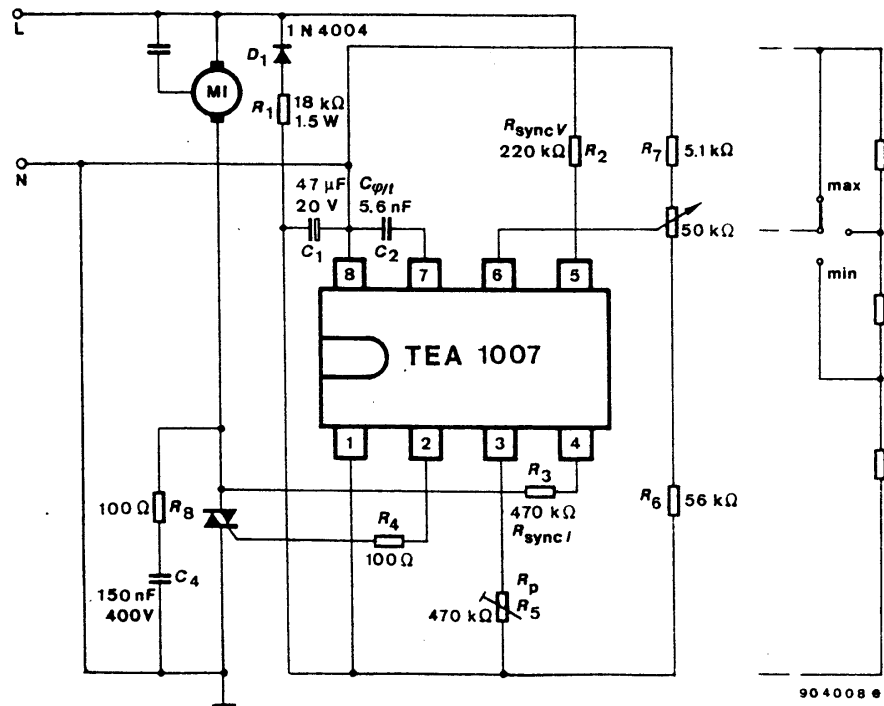


Figure 5. Phase control for fan motors – 230 V ~

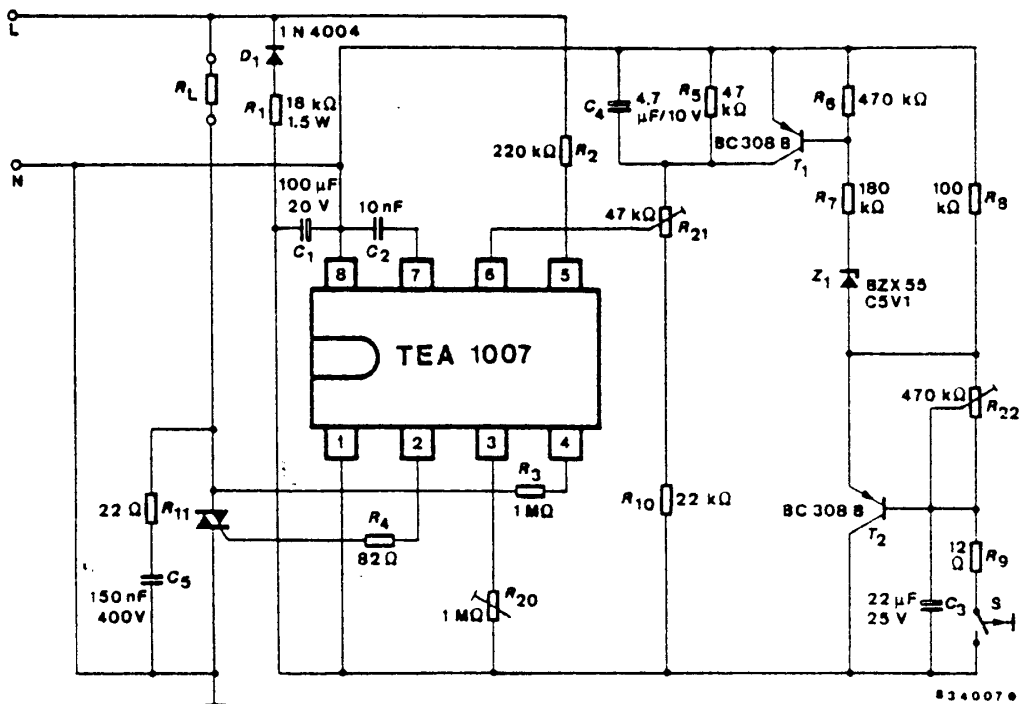


Figure 6. Two-phase time-switch, 230 V ~

The timing switch using the TEA 1007 permits two-phase operation of loads with conduction angle  $\phi$  adjustable as required (see figure 6).

Phase 1:  
 $\varphi = \varphi_{\max}$  adjustable with  $R_{21}$   
 Period  $t = 5$  to  $320$  sec adjustable with  $R_{22}$

Phase 2:  
 $\varphi = \varphi_{\min}$  adjustable with  $R_{20}$   
 Period  $t =$  optional, or up to the pressed time of switch S

Phase 1 begins as soon as the mains voltage is applied. The maximum angle of conduction  $\varphi_{\max}$  can be adjusted by means of  $R_{21}$ . The timing circuit comprises  $T_1$ ,  $T_2$ ,  $Z_1$ ,

$C_3$  and  $R_{22}$ . As the voltage to which  $C_3$  is charged increases, the current through  $Z_1$  decreases. When the potential at the emitter of  $T_2$  has climbed so high that the current through  $Z_1$  becomes zero,  $T_1$  can no longer conduct. The potential on  $R_{21}$  therefore drops. The conduction angle  $\varphi$  decreases to the value  $\varphi_{\min}$ , adjustable by means of  $R_{20}$  (Phase 2).

The transition from  $\varphi_{\max}$  to  $\varphi_{\min}$  takes place continuously following the adjustment of  $R_{22}$  and takes ca. 2 to 20 secs. The time constant of Phase 1, which is also determined by  $R_{22}$ , begins with the release of key S. If S is pressed again before the end of the time constant, a period equal to the complete time-constant is added to the time already run.

The circuit is powered direct from mains via  $D_1$  and  $R_1$  in every negative half-cycle.  $C_1$  smooths the operating voltage which settles at a level of ca. 15.5 V.

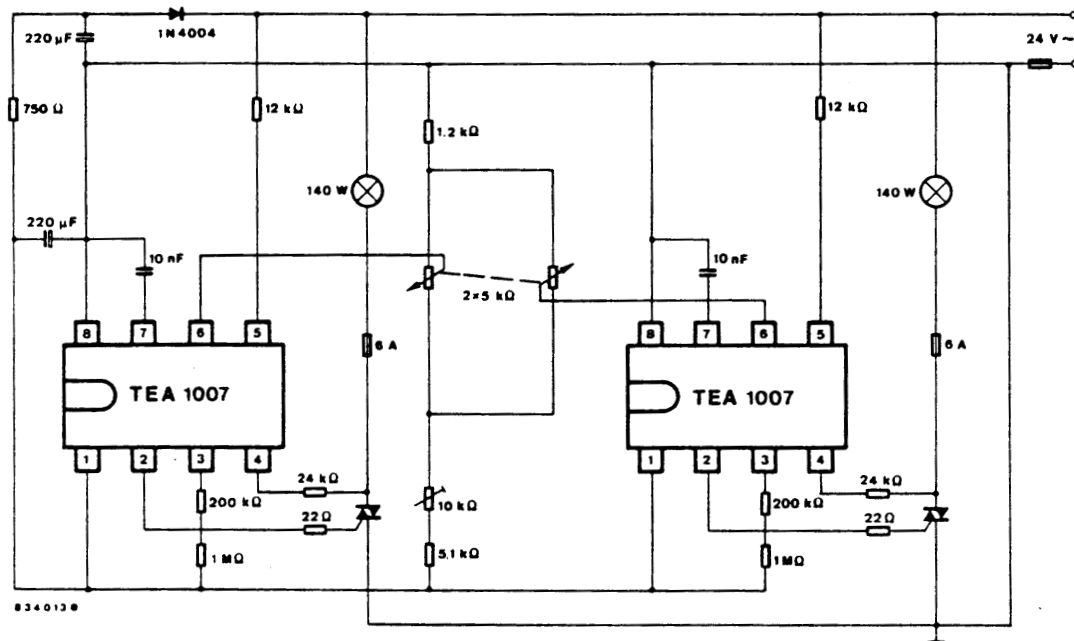
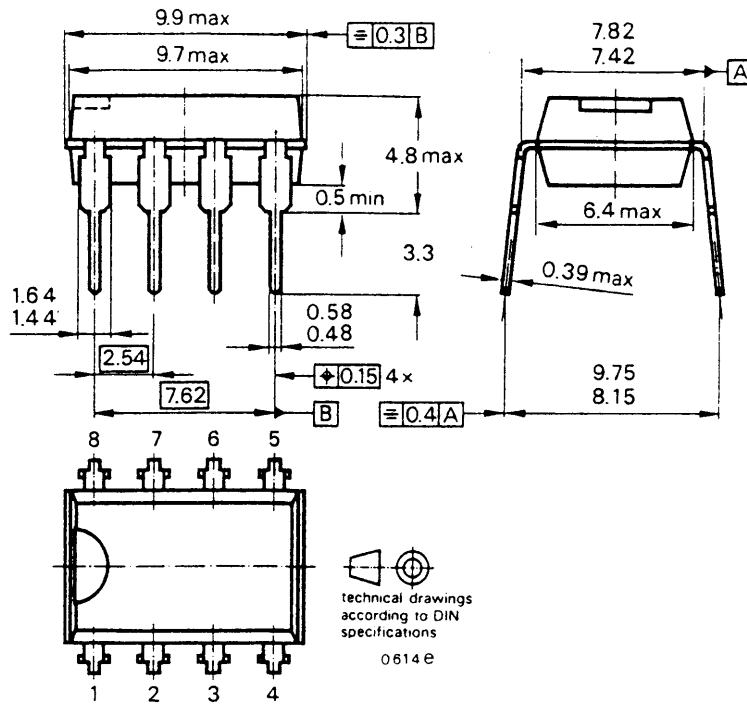


Figure 7. Fading circuit for manual operation

**Dimensions in mm**

Package: DIP8



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1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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