DIMMER IC FOR HALOGEN LAMPS

GENERAL DESCRIPTION

M7237/M7238 are a CMOS integrated circuits designed of digital electronic phase controls for operation of incandescent lamps, low-voltage halogen lamps with in-series connected transformers, and universal as well as split-pole motors. The IC it is possible to generate one defined current pulse per line half cycle. Together with a triac and a few extra passive components, a line-powered phase-control circuit can be designed. The phase-control angle (turn-ON time of the triac) can be set on the two control inputs, $\overline{\text{TI}}$ and EXT of the IC.

The voltage supply to the IC in a two-wire connection is ensured by limiting the angle of current flow to approx 158 °. This makes it simple to exchange mechanical wall switches in conventional lighting installations. The IC's internal logic is synchronized with the line by PLL. Thus a phase control range independent of the line frequency is obtained.

FEATURES

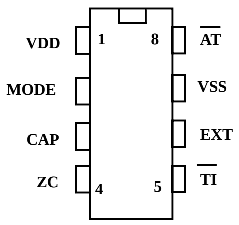
- Touch or pushbutton control of incandescent lamps and transformer-coupled halogen lamps.
- Transformer can be Magnetic or Electronic.
- Automatic safety shutdown.
- Soft tune-on & tune-off.
- PLL synchronization allows use as a Wall Switch.
- Three operating modes.
- Extension input for remote activation.
- 50Hz/60Hz AC line frequency.
- 8 pin DIP package

APPLICATIONS

Wall switch control of ceiling mounted lighting, foot switch control of large floor lamps and hand switch control of table lamps.

PIN ASSIGNMENT

M7237P/M7238P



PIN DESCRIPTION

Pin No.	Pin Name	Description
1	VDD	Positive power supply.
2	MODE	The input is for the 3-state MODE. - See **Table 1** Selects the operating modes：VSS = Mode 0；Float = Mode 1；VDD = Mode 2 .
3	CAP	The input is for the PLL filter capacitor.
4	ZC	The AC Line Frequency is applied to this input through an external RC circuit. The Phase-Lock Loop in the IC synchronizes all internal timings to the AC signal at the ZC input.
5	$\overline{TI}$	A Logic 0 applied to this input alters the $\overline{AT}$ output either by turning it on, turning it off or by changing its conduction angle. Specifically which action takes place is dependent on the type of activation of the $\overline{TI}$ input, namely SHORT or LONG touch and the prior state of $\overline{AT}$ output.
6	EXT	Same functionality as the $\overline{TI}$ input, except that a Logic 1 is the active level at this input. EXT input is intended to be operated from a remote site with long cable connection, when noise can be expected. The sampling method used at this input makes it less sensitive to noise.
7	VSS	Negative power supply.
8	$\overline{AT}$	The $\overline{AT}$ output is a low level pulse occurring once every half- cycle of the AC and is intended to drive the gate of a triad in series with the load. The conduction angle, ø of the $\overline{AT}$ pulse can be varied by means of LONG and SHORT touches at either the $\overline{TI}$ or the EXT input.

TABLE 1					Dimming Direction Reversal (Note 5)
Mode	Short Touch		Long Touch		
	Pre-Touch Ø	Post-Touch Ø	Pre-Touch Ø	Post-Touch Ø	
0	Off	Max (Note 1)	Off / Min.	Varies up from Min.	N/A
	On	Off	Max.	Varies down from Max.	N/A
			Intermediate	Varies from Intermediate	NO
1	Off	Memory (Notes 2, 3)	Off	Varies from Memory (Notes 2, 3,4)	YES
			Min.	Varies up from Min.	N/A
	On	Off	Max.	Varies down from Max.	N/A
			Intermediate	Varies from Intermediate	YES
2	Off	Max (Note 1)	Off / Min.	Varies up from Min.	N/A
	On	Off	Max.	Varies down from Max.	N/A
			Intermediate	Varies from Intermediate	YES

Note 1：A soft turn-on is produced by slowing up the conduction angle, Ø from minimum at the rate of 1.4 ° /4.17ms (60Hz). There are a total of 84 discrete values of Ø.

Note 2：A soft turn-on is produced by slowing up Ø from minimum to memory. Upon power-up the memory value is defaulted to maximum conduction angle.

Note 3：“Memory” refers to the conduction angle , Ø ,which existed prior to the current off-state.

Note 4：A soft turn-on is produced by slewing up Ø from minimum to memory upon which the dimming is started.

Note 5：**NO** = Dimming direction does not reverse from prior dimming direction.

YES = Dimming direction does reverse from prior dimming direction.

N/A = Does not apply.

TIMING CHARACTERISTICS (See Figure 1,2 & 3)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
Fs	AC Frequency	45	—	70	Hz
Ts1	Short Touch (60Hz)	42	—	333	ms
Ts2	Long Touch (60Hz)	342	—	infinite	ms
T_W	AT pulse width (60Hz)	—	130.2	—	us
Phase	Output phase Ø	41	—	158	Degrees
Dø	Ø incremental steps (Total number of steps = 83)	—	1.4	—	Degrees
Ss	Soft-on slew rate	—	1.4	—	Deg / 4.17ms
S_{AA}	A0 to A1/A2 to A0 slew rate	—	1.4	—	Deg / 33.3ms
S_{BA}	A1 to B1/B2 to A2 slew rate	—	1.4	—	Deg / 66.7ms
T_{BD}	B1 to B2 delay	—	—	—	Deg / 500ms

*All timings are based on Fs = 60Hz, unless otherwise specified. 50Hz timings are 1.2 times 60Hz timings.

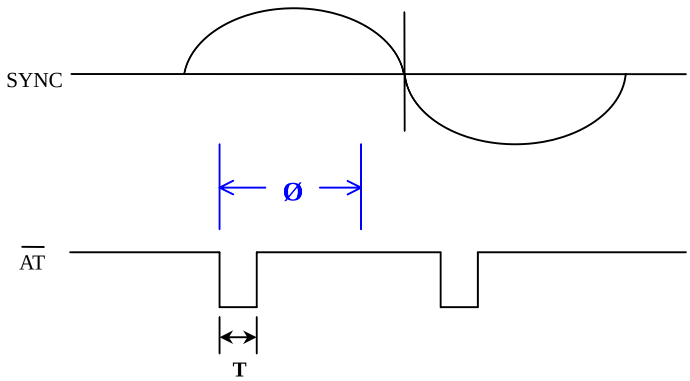
Note 1：Total number of steps = 83.

Note 2：Number of steps from A0 to A1, or A2 to A0 = 68.

Note 3：Number of steps from A1 to B1 or B2 to A2 = 15.

Note 4：Ø is at minimum between B1 and B2. TBD is applicable for M7237 only. For M7238 when minimum Ø is reached, dimming direction reverses only if the Long Touch is terminated and reapplied.

Figure 1. Output phase angle



The functional differences between M7237 and M7238 are：

M7237—When a Long touch is applied, the dimming direction automatically reverses whenever maximum or minimum conduction angles are reached.

M7238—When a Long touch is applied, the dimming stops whenever maximum or minimum conduction angles are reached. In order to change dimming levels from maximum or minimum, Long touch must be removed and reapplied. The purpose of this feature is to allow the user to positively locate maximum and minimum conduction angles.

Note：If the User applies a Long Touch when the TRIG Conduction Angle is within a ”few” degrees of Maximum or Minimum, the TRIG Conduction Angle can move to Maximum or Minimum and stop without the User being able to observe a change in brightness. Therefore, the User should be instructed that if no change in brightness is observed in response to a Long Touch, the Long Touch should be removed and reapplied in order to produce a change in brightness.

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Figure 2. M7237 TRIG , Ø VS. TOUCH ($\overline{TI}$ OR EXT)

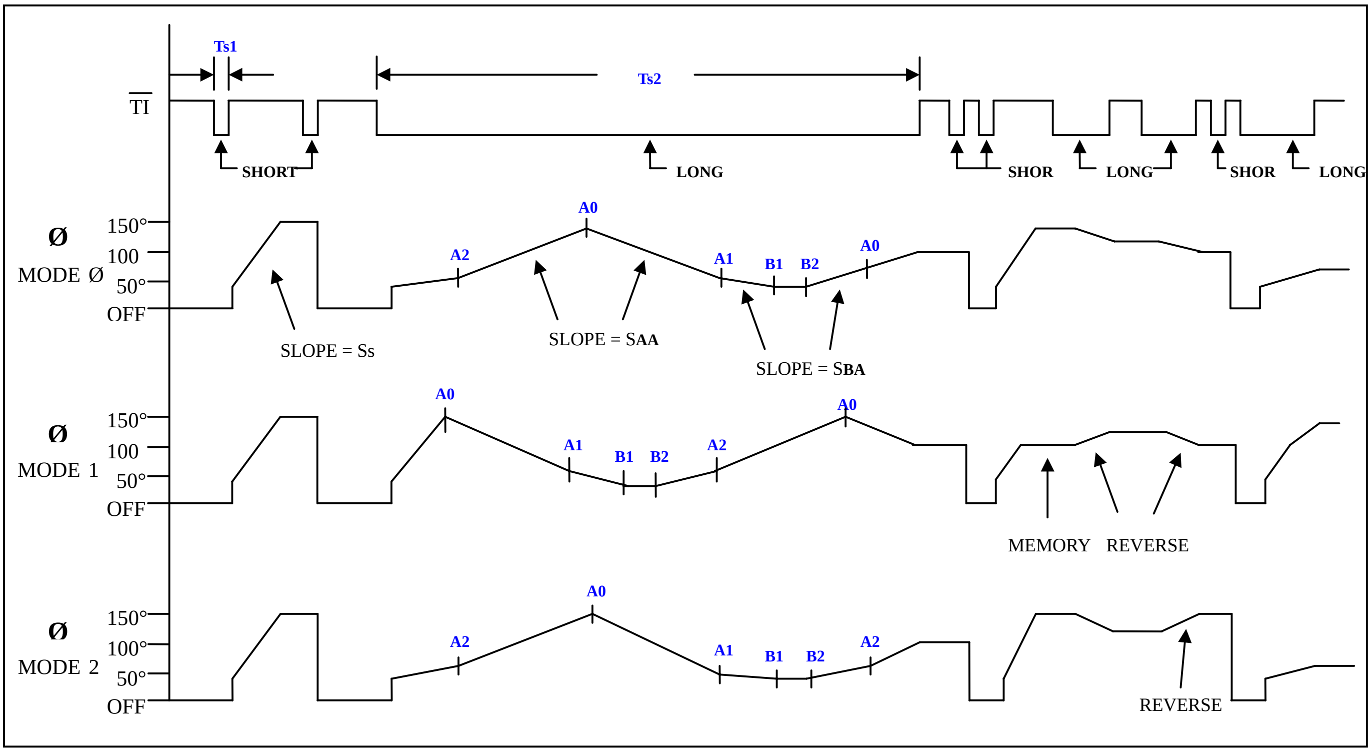
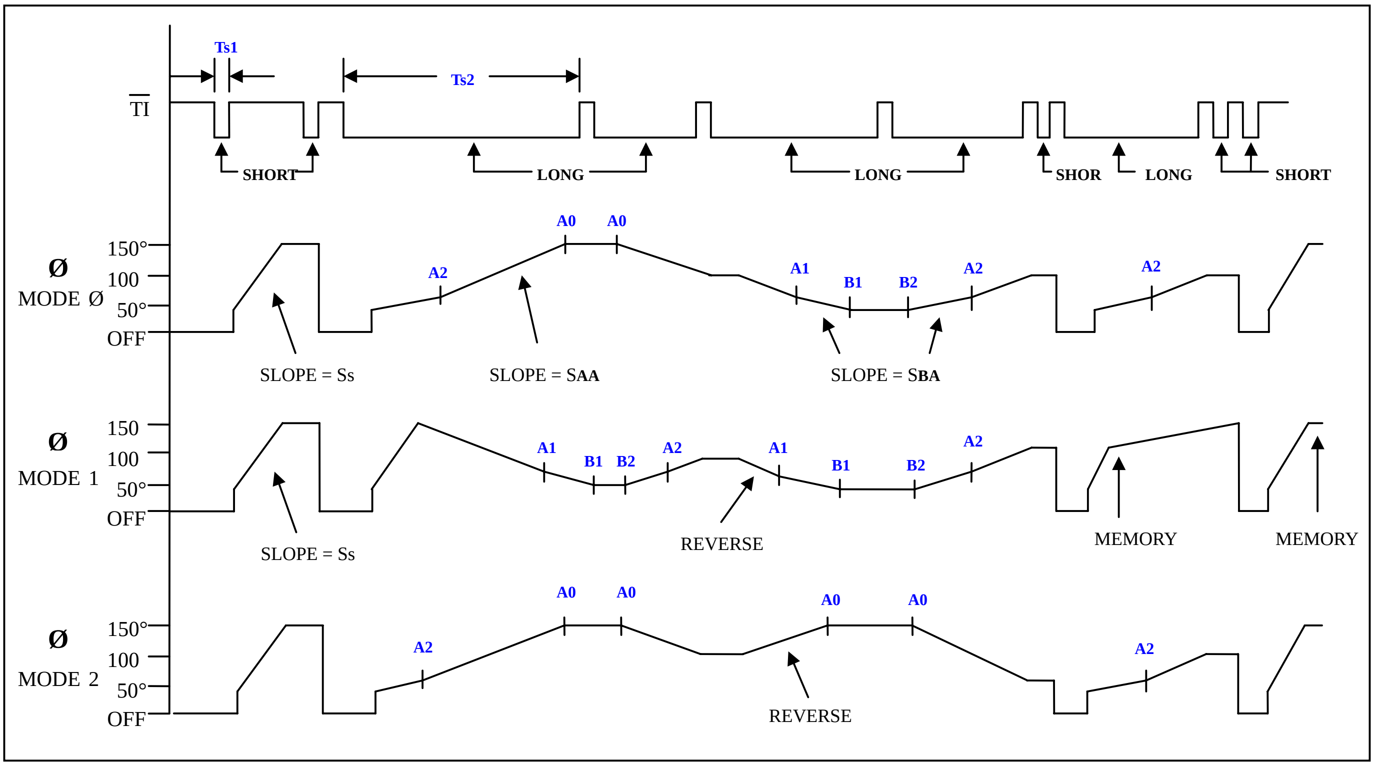


Figure 3. M7238 TRIG , Ø VS. TOUCH ($\overline{TI}$ OR EXT)



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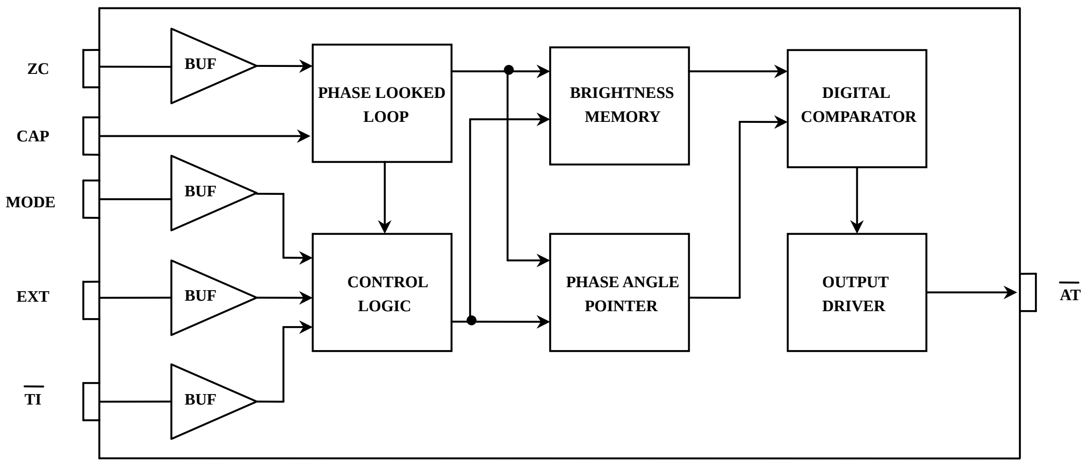
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATING

(TA=25℃)

Parameter	Sym.	Rating	Unit
Power Supply V_{DD} With Respect to V_{SS}	V_{DD} - V_{SS}	+7	V
Voltage On Any Pin		VDD-0.3 to VDD+0.3	V
Operating Temperature	Top	-20 to 70	℃
Storage Temperature		-65 to 150	℃

ELECTRICAL CHARACTERISTICS

Characteristics	Sym.	Min.	Typ.	Max.	Unit	Conditions
Supply Voltage	V_{DD}	4.5	5.0	5.5	V	
Stand by Current	I_{ST}	—	450	550	uA	V_{DD} =5 volt , output unloaded
ZC High level input voltage	V_{IH}	2.9	—	—	Volt	
ZC Low level input voltage	V_{IL}	—	—	2.1	Volt	
EXT $\overline{AT}$ High level input voltage	V_{IEH}	3.5	—	—	Volt	
EXT $\overline{AT}$ Low level input voltage	V_{IEL}	—	—	1.5	Volt	
$\overline{AT}$ Output High voltage	V_{OH}	—	5	—	Volt	
$\overline{AT}$ Output Low voltage	V_{OL}	—	0.2	—	Volt	
$\overline{AT}$ Output Sink Current	I_{SINK}	—	10	—	mA	V_{DD} =5 volt , V_{OL}=V_{DD} -4

OPERATION WITH LOW-VOLTAGE HALOGEN LAMPS

In normal, resistive operation of a phase control circuit there is alternately part of the positive and negative line-voltage half cycle applied to the load via the triac that has started to conduct because of the trigger pulse. Operation of the circuit with a transformer and low-voltage halogen lamp connected is largely identical to the operation of a normal filament lamp due to the primarily resistive nature of the load. In operation with resistive and inductive portions of load, the zero crossing of the current compared to that of the line voltage line is delayed. In operation with heavily inductive loads (eg an idling transformer after lamp failure), a highly lousy state (half cycle operation) can occur after a fault, leading to thermal destruction of the transformer. Control mechanisms integrated into the M7237 serve to protect the load from this situation.

If, for instance, a trigger pulse is missing in a half cycle because of a fault, there will be a considerable increase in current in the transformer into the line shortly after the zero crossing of a voltage wave – after the next firing of the triac at large phase -control angles. If the next trigger pulse comes into phase when the triac is still conducting because of the inductive current lag, it has no effect. It is only the subsequent trigger pulse that will fire the triac again.

The case described above, where only one trigger pulse per line cycle leads to firing of the triac, can turn into a steady-state condition in the absence of further measures.

The M7237 provides the following features to prevent Steady-State Half-Cycle.

Operation：

- Allowance for the conducting state of the triac when setting the trigger pulses. If a trigger pulse, determined by the set firing angle and status of the internal PLL, coincides with the conducting phase of the triac, the trigger pulse will not be output to the triac until after the zero crossing of the current wave.
- Detection of high saturation currents at angles of current flow of more than 180° by sampling the synchronizing input levels. If the frequency of such peak situation current exceeds a value defined in the IC, there will be a safety shutdown.
- Re-triggering if the triac does not remain triggered after the trigger pulse. This can occur in particular on highly inductive loads (idling transformer with a small magnetizing current) and insensitive triacs. Approx. 1.5 ms (1.25 ms at 60 Hz) after each trigger pulse from M7237 the conducting state on the triac is sampled via ZC of the IC. If the triac still remains turned off, one-shot re-triggering will follow. If the frequency of re-triggering exceeds an internally defined limit value, there will be a cutout.

Safety shut down

The purpose of the safety shot down is to prevent thermal destruction of primarily inductive loads (idling transformer) in the event of very lousy instances of operation. Despite the safety precautions that are integrated, you should only use transformers with thermal protection. Safety cutout occurs when the count of an 4-bit up/down counter reaches 15. The count is determined by the ratio of the up/down counting rates. The up-counting rate is the appearance of high saturation currents and re-triggering. A down counting increment is produced when the count is other than zero at every fifteenth line half-wave. The count is zeroed in the off state and when short line outages are detected.

Turning on/off

Short touching (50 to 400 ms) of the sensor area turns the lamp ON or OFF, depending on its preceding state. The switching process is activated as soon as the sensor is released.

Setting of the phase control angle

If the sensor is touched for a longer period (exceeding 400 ms) the angle of current flow will be varied continuously. It runs across the control loop in approximately 7.6 s up and down (e.g. bright–dark–bright) until the sensor is released. Easy operation, even in the lower brightness range of incandescent lamps, is enabled by the following procedure：

The phase control angle is controlled such that the lamp brightness varies physiologically linear with the operating time and pauses for a short period when the minimum brightness is reached.

Using R2 and C4 (synchronizing input) in the application circuit **(Figure 4)**, the angle of current flow can be controlled for purely resistive loads between 45° and 152° of the half-wave.

Interference Immunity

Components C3, C6 and R3 **(Figure 4)** provide for a stable operating voltage and thus for error-free working of the circuit, even in the presence of high frequency line interference (e.g. caused by cutting in and out of mainly active loads).

In the event of short line interruption (≦200ms) the set circuit state with the external wiring shown in **Figure 4** will be maintained. After prolonged line outages (VS≦-3.6V) the circuit will go into the OFF-state.

Upon line outage the synchronization of the internal logic with the line is lost. If the line outage lasts less than three line cycles, the phasing in of the PLL becomes visible by a brief flickering. The setting of the PLL can be influenced within certain limits by the selection that is made with C5 and R10. In general terms, smaller ratings for C5 and larger ratings for R10 will produce shorter settling times of the PLL.

With more inert PLL characteristics there are slightly better values for ripple-control stability (visible fluctuations in brightness when operating incandescent lamps and with ripple-control signal on the line).

If line outages last more than three line cycles, there is blanking for approx. 200 ms after the line recovers so that the settling process of the PLL is not visible.

Operation of Extensions

Long extension lines in installations cause voltages to be coupled in because of their stray capacitance and phase capacitance. Internal limiting structures and appropriate evaluating logic ensure that the circuit can work without interference for stray and phase capacitance up to 100nF.

Even voltage drops up to 10V in the phase conductor between the circuit and the extension button being in phase with the dimming voltage have no effect on the working of the circuit.

Especially at operation with long extension lines, the RC-network R10, C5 should be connected between pins 3 and 7 **(Figure 4)**.

APPLICATION CIRCUIT (Figure 4)

The suggested circuit design of the M7237 performs the following functions：

- Current supply for the circuits (R1, R3, C2, C3, C6, D1, D2).
- Filtered signal for synchronization of the internal time base (PLL circuit) with line frequency (R2,C4). An increase for C4 and R2 causes a slight reduction of the lamp brightness but at the same time an improvement of interference immunity of the internal PLL against line voltage spikes.
- Integration unit for internal PLL circuit (C5) Combining determines within certain limits the following factors
  – Start-up behavior of internal PLL after line failure.
  – Ripple control behavior (periodic shifts of lamp brightness if ripple control signals represent).

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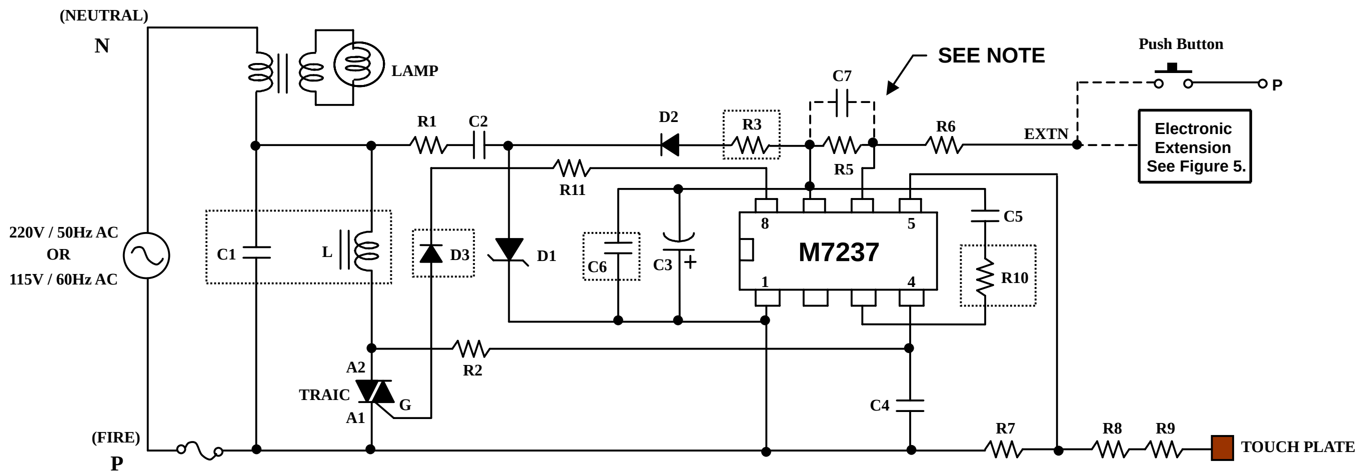
- Protection of the user (R8, R9), Sensitivity setting of the sensor (R7)
- Current limitation in the case of reverse polarity of the extension (R5, R6,C7) Both resistors and C7can be omitted if no extension is connected. C7 is used only with electronic extension and R6 is used only with a pushbutton.
  In this case EXT (Pin 6) must be connected to VSS (Pin 7).—NOTE
- D3：Reduction of positive voltages which may arise during the triggered state at the gate of some triacs, to values below VDD + 0.3V by diode forward voltage. If suitable triacs are used, diode D3 can be omitted.
- L, C1 are used for EMI suppression.

Figure 4. A TYPICAL HALOGEN LAMP DIMMER WALL SWITCH

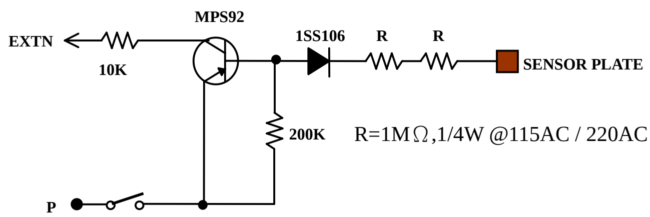


R1	270Ω, 1/2W	115V
	1KΩ, 1W	220V
R2	300KΩ, 1/4W	115V
	680KΩ, 1/4W	220V
R3	0…68Ω	
R5	1.5MΩ, 1/4W	
R6	150KΩ, 1/4W	
R7	0…2KΩ, 1/4W	For Push button
	1…4.7MΩ, 1/4W	For Touch plate
R8,R9	2.7MΩ, 1/4W	115V
	4.7MΩ, 1/4W	220V
R10	330KΩ, 1/4W	
R11	100Ω, 1/4W	

C1	0.15uF, 200V	115V
	0.15uF, 400V	220V
C2	0.22uf, 200V	115V
	0.22uf, 400V	220V
C3	100uF, 10V	
C4	0.022uF, 10V	
C5	0.02uF, 10V	
C6	10…100nF	
C7	0.0039uF, 10V	

D1	5.6V, 1W (Zener)	
D2	IN4148	
D3	IN4148	
L	100uH (RFI Filter)	115V
	200uH (RFI Filter)	220V
TRIAC	BTA04 , BTA12	

Figure 5. ELECTRONIC SWITCH EXTENSION CIRCUIT



* All specs and applications shown above subject to change without prior notice.
(以上電路及規格僅供參考,本公司得逕行修正)