

## PROXIMITY/TOUCH CONTROL HALOGEN LAMP DIMMER

November 2001

### FEATURES:

- Control of incandescent and transformer coupled halogen lamps.
- No-Touch lamp control through optical sensing
- PLL synchronization of AC for wall switch application.
- Extension input for remote control
- Safety-shutdown for transformer malfunction.
- Pin-selectable operating modes
- Single 5V power supply
- 50Hz/60Hz AC line frequency
- LS7232NT (DIP), LS7232NT-S (SOIC) - See Figure 1

### DESCRIPTION:

LS7232NT is a CMOS integrated circuit designed for brightness control of incandescent lamps or transformer coupled low voltage halogen lamps. The brightness is controlled by controlling the firing angle of a triac in series with the lamp and triggered by the LS7232NT. A Phase-Locked-Loop keeps the LS7232NT phase pointer locked in phase with the line voltage.

A unique optical user interface provides for a smooth control of the lamp intensity without the need for touching any sensor plate. A mechanical switch interface for dimming control is also provided which can be used for a remote touch plate. The IC includes features to address problems associated with inductive loads such as transformers in low voltage halogen lamp application. The voltage to current phase lag resulting from the inductance may prevent the triac from shutting off at AC zero crossover and/or prevent the triac from maintaining conduction following the removal of the gate trigger.

These problems are addressed by the LS7232NT in the following manner:

1. Compensation for delayed triac cut-off.  
When trigger pulse is due to occur at a conduction angle which coincides with the on-state of the triac, the trigger pulse is delayed until the triac has turned off. This eliminates the underlying cause of half-waving.
2. Compensation for delayed triac turn-on.  
At the set conduction angle, a triac trigger pulse of 130.2µs (60Hz) is issued by the dimmer IC. If the triac fails to fire, a second trigger pulse of 260.4µs width is issued a milli-second later as a second attempt to fire the triac during the same half-cycle.
3. Safety-Shutdown.  
If the frequency of occurrences of the delayed cut-off and the delayed turn-on exceeds a preset threshold, a shutdown is initiated by turning off the triac trigger pulses. The safety-shutdown threshold value is accumulated in a 4-bit Up/Down counter. The count increments for every occurrence of delayed cut-off or delayed turn-on and decrements once every 8 SYNC pulses (AC line cycles). The count will not decrement below zero. If the count reaches 15, the safety-shut-down is effected.

PIN ASSIGNMENT - TOP VIEW

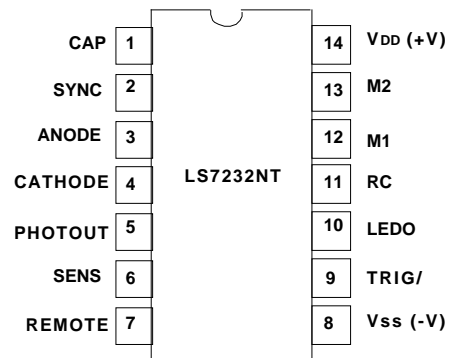


FIGURE 1

The LS7232NT can be configured in 7 different modes of dimming and timing off functions selected by two 3-state mode pins.

### INPUT/OUTPUT DESCRIPTION:

#### CAP (Pin 1)

PLL filter capacitor input. A 0.02µF capacitor is required at this input for the optimal operation of the PLL.

#### SYNC (Pin 2)

The phase pointer for the triac trigger signal is synchronized with the 50Hz/60Hz AC voltage applied at the SYNC input by the internal PLL. The triac On/Off status information is also derived from this input.

#### ANODE (Pin 3) CATHODE (Pin 4) and PHOTOUT (Pin 5)

These three pins constitute the input/outputs of a trans-conductance and voltage amplifier pair (See Fig. 6) for converting the current from a photo-diode to a voltage stimulus for application at the SENS input. The photo-signal is used in lieu of a touch plate for a touchless dimmer system. The output at PHOTOUT is governed by the following equation:

$$V_{OUT} = V_{DD}/2 + 2I_D R_f$$

Where  $V_{DD}$  = Supply Voltage

$I_D$  = Current in Photo-diode connected between ANODE and CATHODE

$R_f$  = Feedback resistance between PHOTOUT and CATHODE

A potentiometer is used for  $R_f$  for controlling the sensitivity of the photo-amplifier system.

**SENS (Pin 6)**

A positive signal applied at the SENS input controls the turn-on, turn-off and dimming function of the LS7232NT. The SENS input is designed to operate with very low levels of signal, so that it can be directly interfaced with the photoamplifier output. Signal at the SENS input is amplified with a gain of 30. If a photo-sensor is not to be used, the SENS input can easily be adapted to a touch plate.

Signals at the SENS input are classified as SHORT touch and LONG touch. Signals between 50ms and 350ms constitute a SHORT touch, whereas signals longer than 350ms constitute a LONG touch. The functions of these two types of touches are explained in the mode description section.

SENS input has an internal pull-down resistor of 10k .

**REMOTE (Pin 7)**

For performing dimming operation from remote sites or through wire extensions, the REMOTE input is used. This input is sampled twice during both negative and positive half cycles of the AC, rendering it more immune to noise and hence more suited for carrying signals over extension wires.

**Vss (Pin 8)**

Supply voltage, negative terminal.

**TRIG/ (Pin 9)**

Trigger output for driving the gate of a triac. A negative pulse of nominally 130.2μs duration is generated at this output which can be varied between 19.7° and 119.5° from the zero-crossover of the AC during every half cycle. The control of conduction angle of the TRIG/ output is effected by Short and Long touches at the SENSE and REMOTE inputs.

**LEDO (Pin 10)**

A positive pulse of 32μs is generated at this output during every negative half-cycle of the AC. If the TRIG/ output is Off, the LEDO is generated nominally 911μs after the AC zero-crossover in the negative half-cycles. If the TRIG/ output is on, the LEDO tracks the TRIG/ output signal and is generated 170μs ahead of the TRIG/ output, during every negative half-cycle of the AC.

The LEDO is used to drive an infra-red LED. When a reflecting object, such as a human hand, is brought close to the infrared LED, the light is reflected back to the Photo-diode, which is mounted in physical proximity to the infra-red LED. The change of intensity of the received light by the photo-diode results in a change of the photo-diode current which in turn is amplified by the transconductance amplifier as described in the ANODE input section.

**RC (Pin 11)**

A resistor-capacitor pair connected externally to the RC input constitutes the timing element for the delay generation in Modes 4, 5, 6, and 7. The delay is given by the expression,  $t_{RC} = 63RC$ .

**M1 and M2 (Pin 12 and Pin 13)**

Each of these inputs are 3-state inputs, namely Low (L), High (H) and Float (F). The logic levels of these two inputs together, configures the operating modes of the LS7232NT according to Table 1.

**MODE DESCRIPTIONS:**

See Figures 2, 3, and 4 for further explanations.

**MODE 1** - Touch causes the TRIG/ output to toggle between Off and Max. The Off to Max transition slews in 350ms(tr). Long and Short Touch operate in identical manner. Leading edge touch sense (change occurs upon initiation of touch)

**MODE 2** - Same effect for Short Touch as in Mode 1. Long Touch causes the output to sweep between conduction angles of 38° (Min) and 155° (Max) in increments of 1.4°. The sweep direction automatically reverses at Min and Max. Sweep direction also reverses for every Long Touch. Trailing edge sensing for Short Touch. (Change occurs upon removal of touch.)

**MODE 3** - Same as Mode 2 except for Short Touch the output toggles between Off and Memory. Memory is updated with the long touch.

**MODE 4** - Same as Mode 2 except the On to Off operation with Short Touch is delayed. At the termination of the Short Touch the output level instantaneously drops by an amount of  $\emptyset$  to indicate the beginning of the turn-off delay,  $t_{RC}$ . At the end of the delay, the output slews off at a rate of 56°/s. The delay  $t_{RC}$  is controlled by a resistor-capacitor pair at the RC (Pin 11) input, according to the following expression:

$$t_{RC} = 63RC$$

The magnitude of  $\emptyset$  is dependent on the pre-touch intensity from where the turn-off delay is initiated and can have one of the values in Table 2 (See Fig. 2 and 3).

**MODE 5** - Same as Mode 4, except a Short Touch in the Off state switches the output to memory.

**MODE 6** - Same as Mode 4, except that there is no dimming function in Mode 6. Both Short and Long touches operate as Short Touch (leading edge touch sense).

**MODE 7** - Output switches from Off to Max with either Short or Long Touch (leading edge touch sense). After a delay of  $t_{RC} = 63 RC$  (See description of Mode 4) the output drops by an angle  $\emptyset$  according to Table 2. After another fixed delay of 10sec ( $t_f$ ) the output slews off in 2sec ( $t_{d7}$ ) at the rate of 56°/sec. A touch during  $t_{RC}$  time out has no effect. A touch during  $t_f$  and  $t_{d7}$  timeouts aborts the timeout and restores output to Max.

**TABLE 1. OPERATING MODES**

M1	M2	MODE	DESCRIPTION
L	L	1	ON - OFF
L	F	2	ON - OFF - DIMMER
L	H	3	ON - OFF - MEMORY - DIMMER
F	F	4	ON - DELAYED_OFF - DIMMER
F	H	5	ON - DELAYED_OFF - MEMORY-DIMMER
F	L	6	ON - DELAYED_OFF
H	L	7	ON - AUTO_OFF_TIMER
H	F	X	NOT ALLOWED
H	H	X	NOT ALLOWED

**TABLE 2. BRIGHTNESS DROP AT DELAY START,  $\emptyset$** 

PRE-TOUCH CONDUCTION ANGLE	$\Delta\emptyset$
155° to 130°	-35°
129° to 115°	-25°
114° to 95°	-20°
94° to 45°	-10°
44° to 38°	Instantaneous Off

**ABSOLUTE MAXIMUM RATINGS:**

PARAMETER	SYMBOL	VALUE	UNIT
DC Supply Voltage	V <sub>DD</sub> - V <sub>SS</sub>	+7	V
Any Input Voltage	V <sub>IN</sub>	V <sub>SS</sub> - 0.3 to V <sub>DD</sub> + 0.3	V
Operating Temperature	T <sub>A</sub>	0 to +90	°C
Storage Temperature	T <sub>STG</sub>	-65 to +150	°C

**DC ELECTRICAL CHARACTERISTICS:** (T<sub>A</sub> = 25°C, V<sub>DD</sub> = +5V, All voltages referenced to V<sub>SS</sub>)

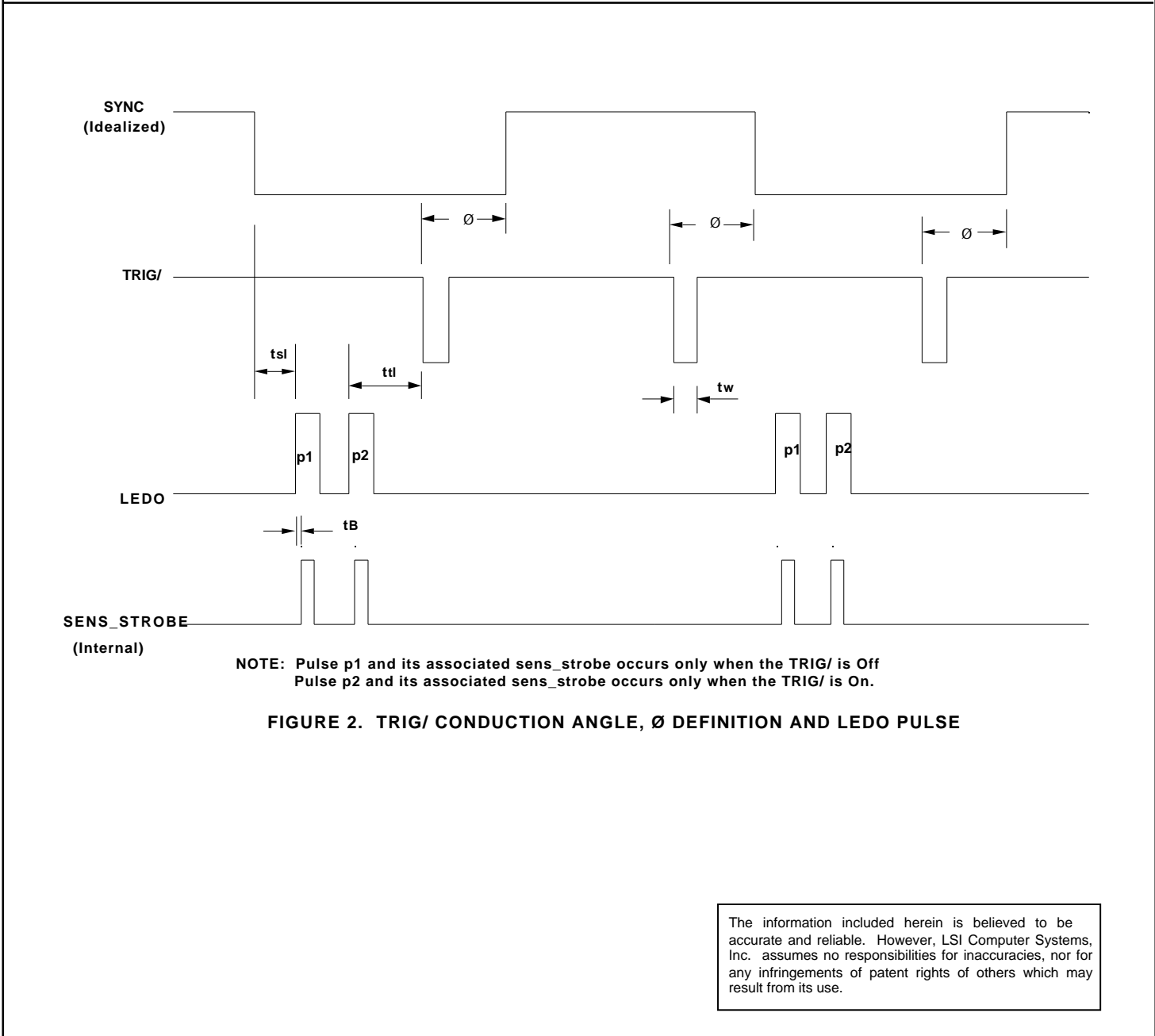
PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	CONDITION
Supply Voltage	V <sub>DD</sub>	4.5	5.0	5.5	V	-
Supply Current	I <sub>DD</sub>	-	400	500	µA	Output unloaded
<b>Input Logic Levels:</b>						
SYNC Lo	-	-	-	2.0	V	-
SYNC Hi	-	3.0	-	-	V	-
REMOTE Lo	-	-	-	1.5	V	-
REMOTE Hi	-	3.5	-	-	V	-
SENS Lo	-	-	-	50	mV	-
SENS Hi	-	150	-	-	mV	-
RC Lo	-	-	-	2.0	V	-
RC Hi	-	3.0	-	-	V	-
<b>Output Current:</b>						
LEDO Sink	-	-1.0	-1.5	-	mA	V <sub>O</sub> = 0.5V
LEDO Source	-	10.0	14.0	-	mA	V <sub>O</sub> = 2.2V
TRIG/ Sink	-	-35.0	-	-	mA	V <sub>O</sub> = 3.5V
RC Sink	-	-3.0	-4.0	-	mA	V <sub>O</sub> = 2.0V

**TRANSIENT CHARACTERISTICS** (See Figures 2, 3, 4 and 5):

All time parameters are based on 60Hz SYNC. For 50Hz a multiplication factor of 1.2 should be used.

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	CONDITION
SYNC Frequency	f <sub>s</sub>	40	-	70	Hz	-
Short Touch	t <sub>s</sub>	50	-	350	ms	-
Long Touch	t <sub>L</sub>	350	-	infinite	ms	-
TRIG/ Pulse Width	T <sub>w</sub>	-	130.2	-	µs	-
Conduction Range	Ø	38	-	155	deg	-
Ø increments	Ø <sub>s</sub>	-	1.4	-	deg	Ø = 84Ø <sub>s</sub>
Short Touch: Off to Max (Slew Time)	t <sub>1</sub>	-	350	-	ms	-
Long Touch: Ramp Time between 38° & 59°	t <sub>2</sub>	-	1.0	-	sec	-
Ramp Time between 59° & 155°	t <sub>3</sub>	-	2.27	-	sec	-
Dwell at min	t <sub>4</sub>	-	500	-	ms	-

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	CONDITION
Timer Resistor	R	200	-	2M	Ohm	
Timer Capacitor	C	0.1	10.0	-	$\mu$ F	
Timer Delay	$t_{RC}$	$1e^{-3}$	-	1200	sec	$t_{RC} \ 63RC$
Slew Off Rate	$t_{sf}$	-	42	-	deg/sec	60Hz
		-	35	-	deg/sec	50Hz
Slew Off Delay	$t_d$	-	$\emptyset D/t_{sf}$	-	sec	
Pre-Off Delay (Mode 7)	$t_f$	-	10	-	sec	
Slew-Off Delay (Mode 7)	$t_{d7}$	-	2	-	sec	
LEDO Pulse Width	-	-	32	-	$\mu$ s	
SYNC to LEDO delay	$t_{sl}$	-	918	-	$\mu$ s	
LEDO to TRIG/ delay	$t_{tl}$	-	170	-	$\mu$ s	
LEDO to Strobe delay	$t_B$	-	24	-	$\mu$ s	



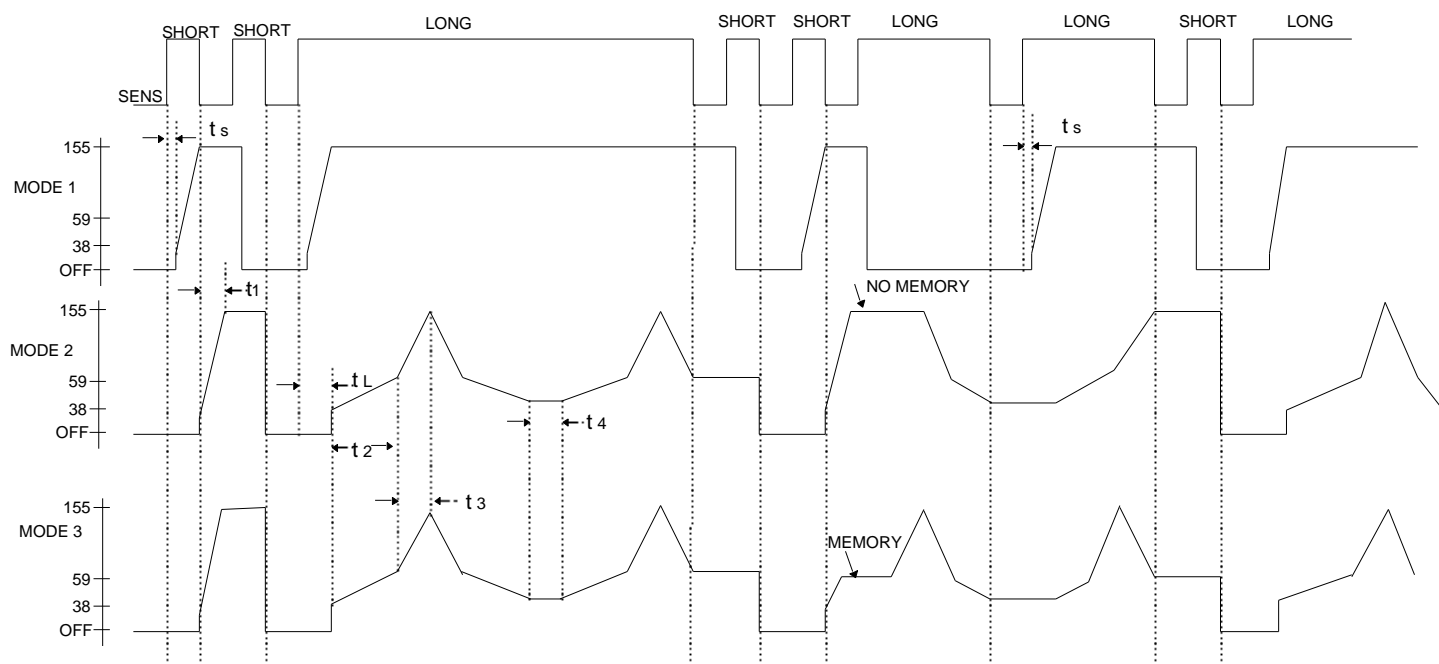


FIGURE 3. MODES 1, 2 and 3

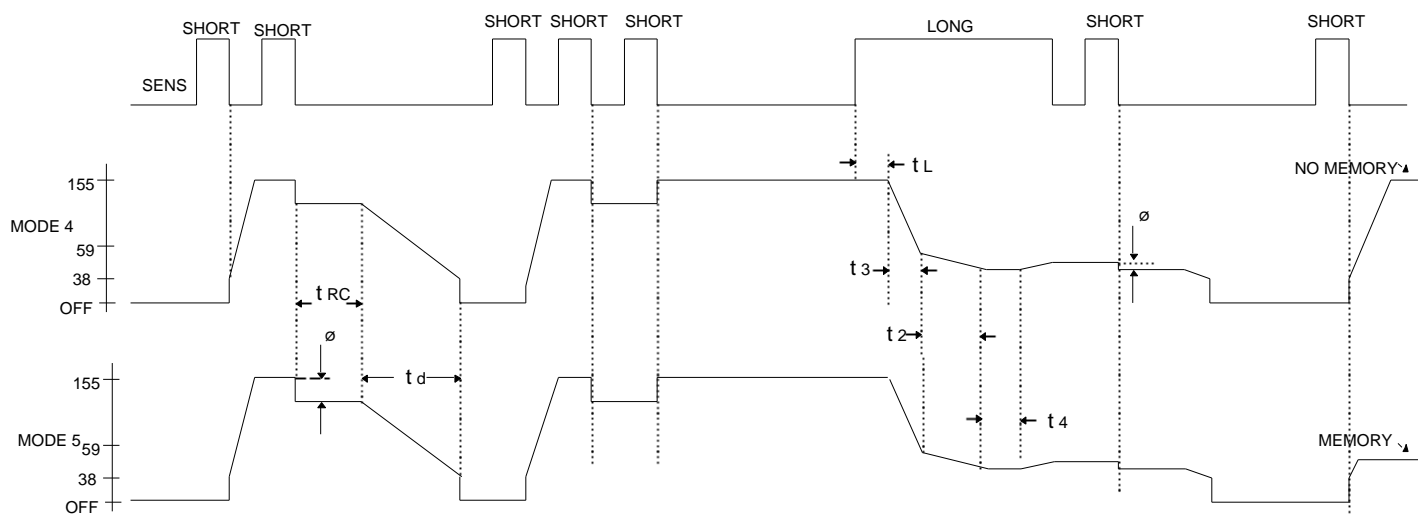


FIGURE 4. MODES 4 and 5

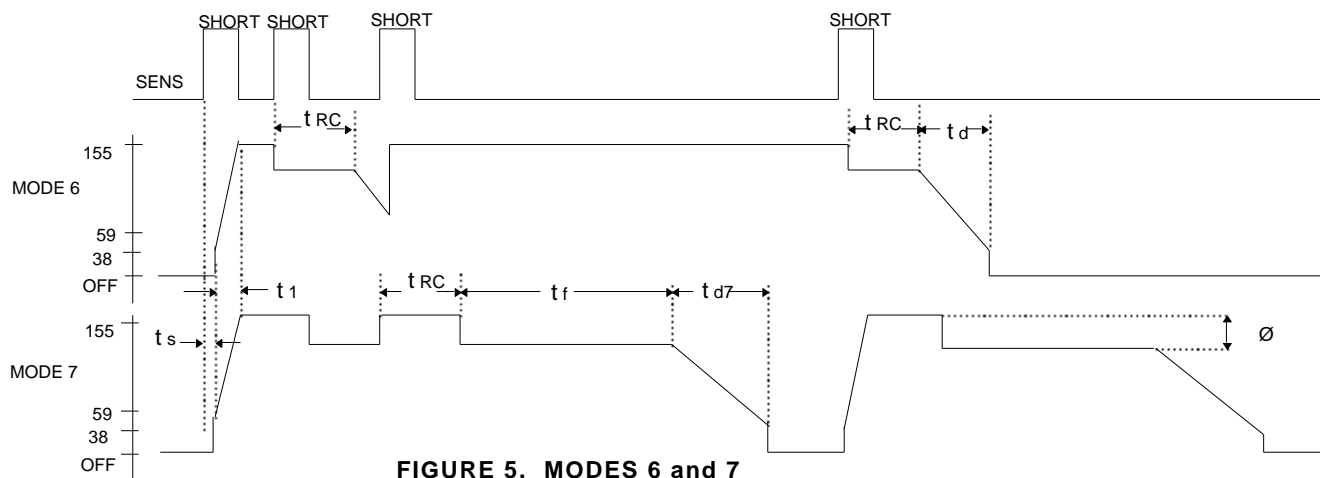


FIGURE 5. MODES 6 and 7

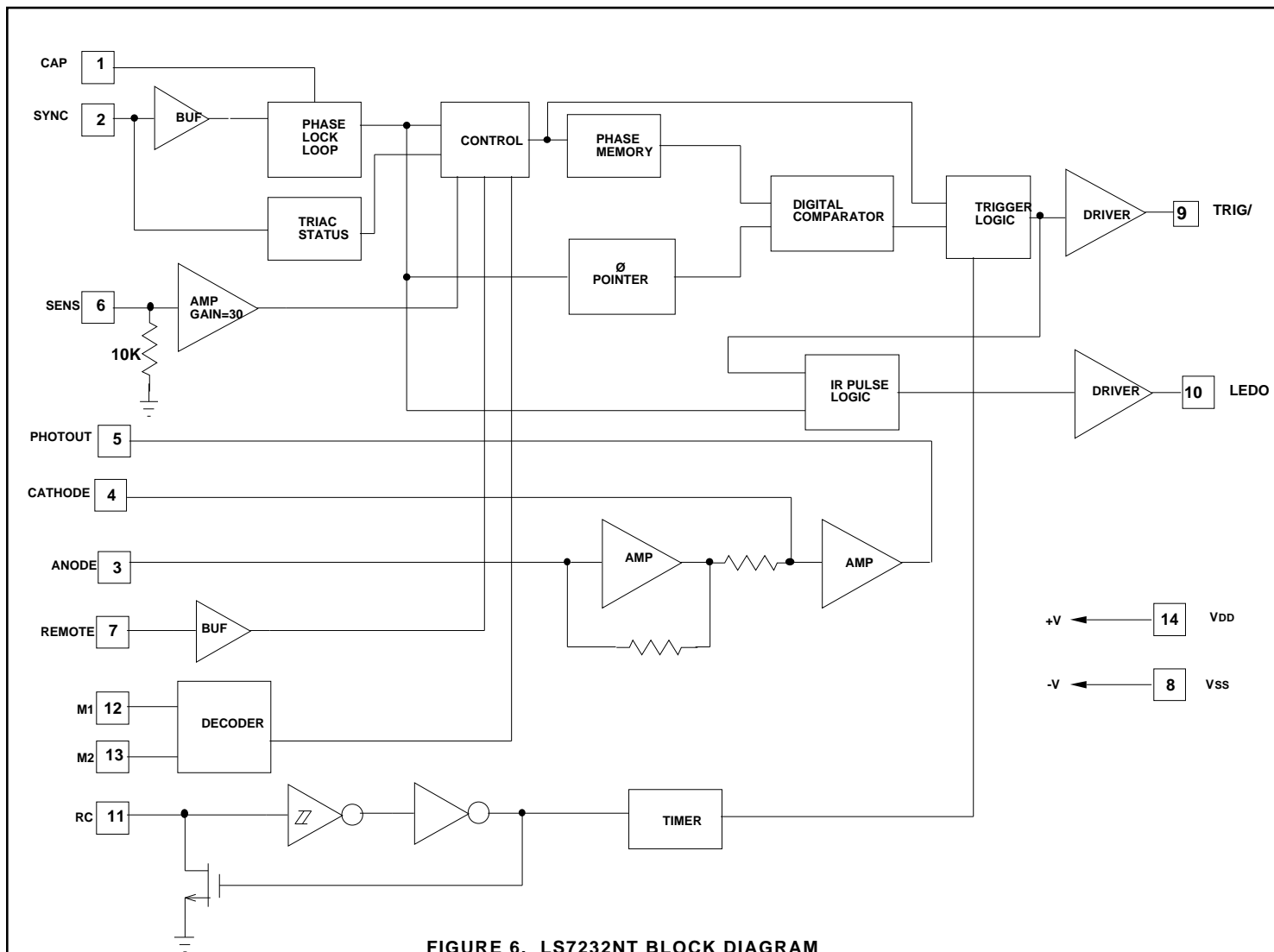
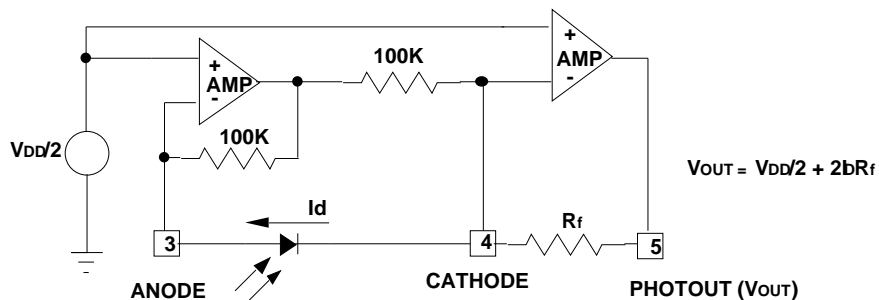
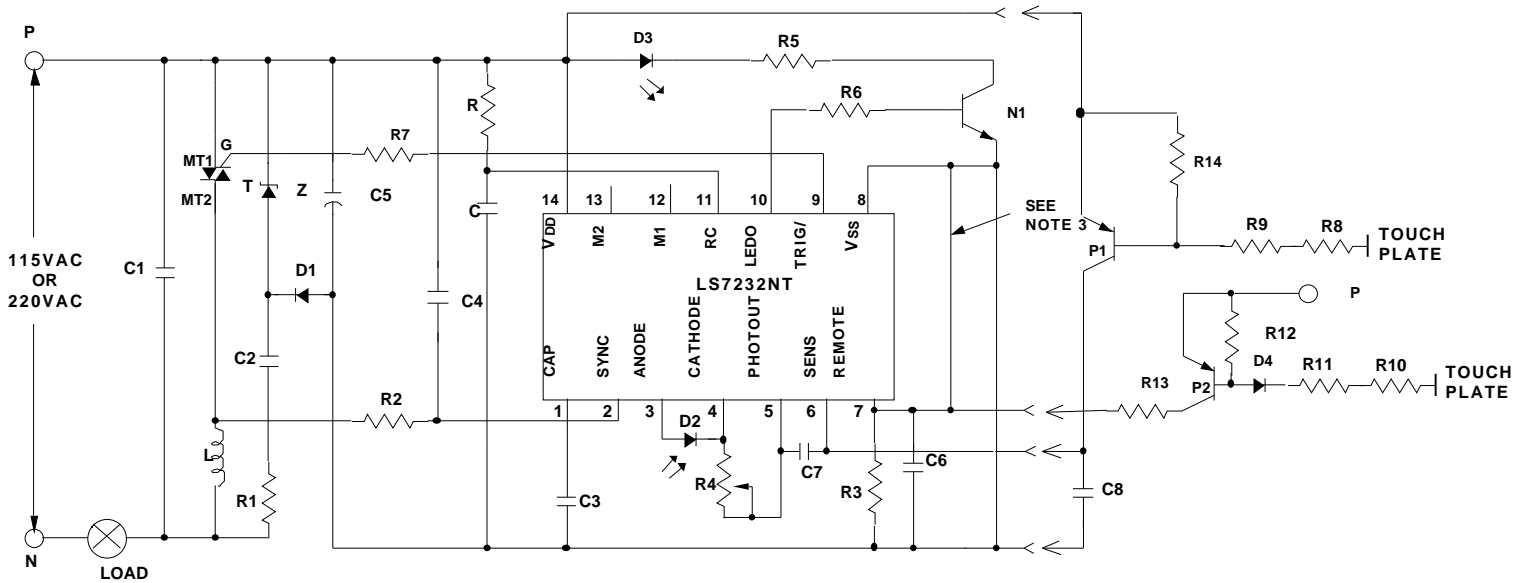


FIGURE 6. LS7232NT BLOCK DIAGRAM

FIGURE 7 . PHOTO AMPLIFIER WITH PHOTO DIODE AND GAIN RESISTOR ,  $R_f$



**FIGURE 8. A TYPICAL DIMMER CIRCUIT WITH NO-TOUCH OPTICAL SENSING AND TOUCH PLATE OPTIONS**



- NOTES**
- 1) For a No-Touch system, the infra-red transmit diode D3 and and receive D2 should be placed in physical proximity so that when a hand is placed in front of D2 and D3, reflected light from the hand is received by the IR receiver D3 to produce a touch impulse.
  - 2) If a touchplate is used the following parts should be in: R8, R9, C8 and P1.  
If infrared detector is used the following parts should be in: D2, D3, R4, R5, R6, C7 and N1.
  - 3) If remote sensing is not used the following parts may be removed: R3, R10, R11, R12, R13, C6 and P2.  
If remote sensing is used these parts should be in and the connection between Pin 7 and Pin 8 must be broken.
  - 4) The load is either an incandescent lamp or the primary of a step-down transformer for a low voltage halogen lamp.

## 115V

- C = 0.1 $\mu$ F to 10 $\mu$ F, 12V  
 C1 = 0.15 $\mu$ F, 200V  
 C2 = 0.22 $\mu$ F, 200V  
 C3 = 0.02 $\mu$ F, 12V  
 C4 = 0.002 $\mu$ F, 12V  
 C5 = 200 $\mu$ F, 12V  
 C6 = 0.1 $\mu$ F, 12V  
 C7 = 0.003 $\mu$ F, 12V  
 C8 = 0.1 $\mu$ F, 12V  
 R1 = 270  $\Omega$ , 1/2W  
 R2 = 680k  $\Omega$ , 1/4W  
 R3 = 1.5M  $\Omega$ , 1/4W  
 R4 = 500k  $\Omega$ , 1/8W Pot.  
 R5 = 51  $\Omega$ , 1/4W  
 R6 = 1k  $\Omega$ , 1/4W  
 R = 200  $\Omega$  to 2M  $\Omega$ , 1/4W  
 R7 = 51  $\Omega$ , 1/4W  
 R8, R9 = 2.7M  $\Omega$ , 1/4W  
 R10, R11 = 2.7M  $\Omega$ , 1/4W  
 R12 = 200k  $\Omega$ , 1/4W  
 R13 = 2k  $\Omega$ , 1/4W  
 R14 = 1 to 5M  $\Omega$ , 1/4W  
 D1 = IN4148  
 D2 = SFH20S, IR Receiver diode  
 D3 = LD271, IR Transmitter diode  
 D4 = IN4148  
 Z1 = 5.6V, 1W (Zener)  
 (2) T1 = Q2004L4 Triac (Typical)  
 L = 100 $\mu$ F, RFI Filter  
 N1 = MPS8099, NPN  
 P1, P2 = MPS8599

## 220V (1)

- (1) All components are the same as 115V except as listed below:

- C1 = 0.15 $\mu$ F, 400V  
 C2 = 0.22 $\mu$ F, 400V  
 R1 = 1k  $\Omega$ , 1W  
 R2 = 1.5M  $\Omega$ , 1/4W  
 R8, R9 = 4.7M  $\Omega$ , 1/4W  
 (2) T1 = Q4004L4 Triac (Typical)  
 L = 200 $\mu$ F, RFI Filter

- (2) For loads exceeding 6A, use an Alternistor