LSI/CSI

LS7540

ISO 9001 REGISTERED FIRM A3800

November 2007

AGC TOUCH CONTROL LIGHT SWITCH with SOFT-OFF

FEATURES:
• Touch or pushbutton control of incandescent lamps.
• Touch Sensitivity guaranteed to 600pF Touch Plate Capacitance.
• Touch Operation is independent of line plug polarity.
•.See **OPERATION** description below.
• 50/60 Hz Line Frequency.
• 5V Operation (VDD - VSS).
• LS7540 (DIP); LS7540-S (SOIC) **- See Figure 1 -**

APPLICATIONS:
• Wall switches and adapter modules for converting
  small table lamps and large floor lamps to touch control.

DESCRIPTION:
The LS7540 is a CMOS integrated circuit for controlling the brightness of incandescent lamps by touch (**Figures 5, 6, 8**) or pushbutton (**Figures 7, 9**). When the LS7540 TOUCH input is connected to a lamp body, any metallic part of the lamp becomes a touch plate. A built-in AGC circuit allows for a wide range of lamp sizes to be used, ranging from small table lamps to large floor lamps. The brightness is controlled by varying the conduction angle of a triac in series with the lamp and triggered by the TRIG/ output. Between off and maximum, there are 124 steps of brightness levels, level zero being off and level 124 being maximum. The phase reference of the TRIG/ signal with respect to the AC line is maintained through the SYNC input.

OPERATION
The On/Off and brightness control of the lamp is described below:

• In the off-state, a single touch will turn the lamp to full-on.

• At full-on, a single touch will start a **soft-off** dim-cycle causing the brightness to diminish gradually until the lamp turns off. The **soft-off** feature provides light for the User to exit the area. The **soft-off** dim-cycle time is programmed by an external RC con nected to Pin 6. With no RC connected to Pin 6, the **soft-off** dim-cycle time = 0.

• During a dim-cycle a single touch will stop the dim-cycle and lock in the brightness present at that time. Another touch will restart the dim-cycle from the present brightness causing the brightness to ramp down towards off again. The start and stop of dim-cycle can be repeated over and over again until the lamp turns off. This feature gives the User full control in setting the light intensity.

INPUT/OUTPUT DESCRIPTION:

CLOCK Input (Pin 1)
An external resistor connected between this input and VDD, along with an internal capacitor and oscillator stage, generates a clock which is used for all timing functions. The recommended value of this resistor for 50Hz and 60Hz operation is specified in the **ELECTRICAL CHARACTERISTICS**.
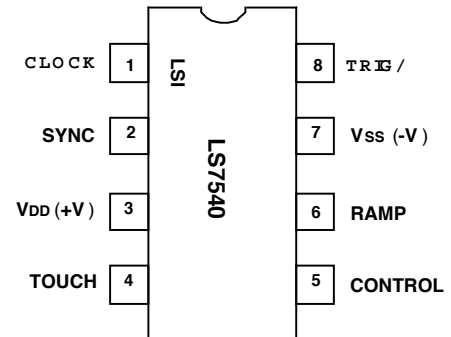
PIN ASSIGNMENT
TOP VIEW

CLOCK	1	8 TRIG/
SYNC	2	7 VSS (-V)
VDD (+V)	3	6 RAMP
TOUCH	4	5 CONTROL

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FIGURE 1

SYNC Input (Pin 2)
50Hz or 60Hz AC input for zero crossing detection.

VDD (Pin 3)
Supply voltage positive terminal.

TOUCH Input (Pin 4)
Input for sensing that a touch has been made on a lamp surface or other touch plate. This action alters the state of the TRIG/ output as described in the Touch Operation section of the General Description.

CONTROL I/O (Pin 5)
An external R-C network connected between this pin and VDD establishes the controlling feedback for the AGC Loop.

RAMP Input/Output (Pin 6)
The ramp down rate of the brightness in the dimming cycle is regulated by a resistor-capacitor (RC) pair connected to the RAMP input. The ramp rate is equal to $4T_{RC}$ per step, where $T_{RC} = 0.48RC$. Total ramp down time (T_T) from maximum brightness to off is equal to $496T_{RC}$.

Example: R = 200kΩ, C = 0.22uF;
$T_{RC} = 0.48 \times (200 \times 10^3) \times (0.22 \times 10^{-6}) = 0.02$ sec.
Ramp rate = $4 \times T_{RC} = 0.08$ sec/step;
Total ramp time, $T_T = 496 \times T_{RC} = 9.92$ sec.

Vss (Pin 7)
Supply voltage negative terminal.

TRIG/ Output (Pin 8)
The TRIG/ output produces a negative pulse every half cycle of the AC line period to turn on a triac in series with the lamp or any other load device. The brightness of the lamp is regulated by regulating the conduction angle, Ø (See Fig. 2) of the TRIG/ signal. The conduction angles at maximum brightness (level 124) and mimimum brightness (level 1) are 162° and 50° with 0.91° incremental steps.
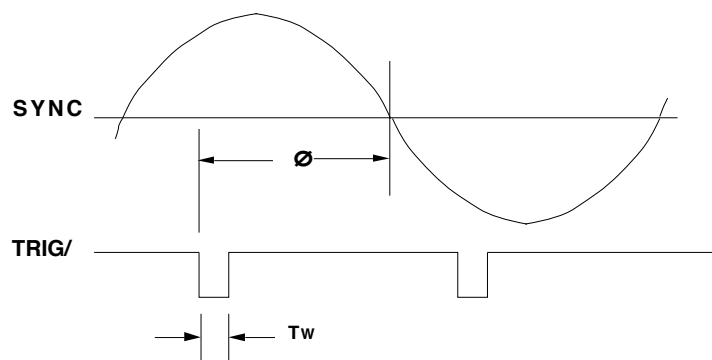
ABSOLUTE MAXIMUM RATINGS:

PARAMETER	SYMBOL	VALUE	UNIT
DC supply voltage	V_{DD} - V_{SS}	+6	V
Any input voltage	V_{IN}	V_{SS} - 0.3 to V_{DD} + 0.3	V
Operating temperature	T_A	-20 to +85	°C
Storage temperature	T_{STG}	-65 to +150	°C

ELECTRICAL AND TRANSIENT CHARACTERISTICS:

(All voltages referenced to V_{SS}. T_A = +25˚C unless otherwise specified.)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	CONDITIONS
Supply Voltage	V_{DD}	+4.5	5.0	+5.5	V	-
Supply Current	I_{DD}	-	-	500	uA	Output off, V_{DD} = +5.0V
TRIG/ Sink Current Vo = V_{DD} - 3V	I_O	-50	-	-	mA	V_{DD} = +5.0V
TRIG/ Source Current Vo = V_{DD} - 0.2V	I_O	+0.1	-	-	mA	V_{DD} = +5.0V
TRIG/ Pulse Width	T_W	-	105	-	μsec	RC = 300kΩ, 60Hz
		-	126	-	μsec	RC = 360kΩ, 50Hz
CLOCK Resistor	-	-	350	-	kΩ	60Hz
	-	-	420	-	kΩ	50Hz
CONTROL Resistor	-	-	10	-	MΩ	-
CONTROL Capacitor	-	-	1	-	μF	-
Touch Plate Capacitance	-	-	-	600	pF	-
Touch Duration	T_S	67	-	-	ms	60Hz
	T_S	80	-	-	ms	50Hz
Conduction Angle	Ø	50	-	162	deg	-
Ø incremental steps (Note 1)	ΔØ	-	0.91	-	deg	-
RAMP Resistor	R	2	-	no limit	kΩ	-
RAMP Capacitor	C	200	-	no limit	pF	-
RAMP RC	T_{RC}	25	-	no limit	μs	60Hz
RAMP RC	T_{RC}	30	-	no limit	μs	50Hz
RAMP Rate	-	-	4T_{RC}	-	sec/step	-
Max to off slew time	T_T	-	496T_{RC}	-	sec	-

Note 1: Total number of steps = 124.

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FIGURE 2. TRIG/ OUTPUT CONDUCTION ANGLE, Ø

SYNC

Ø

TRIG/

Tw

TOUCH

Ts

DIM CYCLE

MAX

DIM CYCLE

MAX

DIM CYCLE

Ø 180º
   120º
   60º
   0º

OFF

MIN

OFF

T$_T$
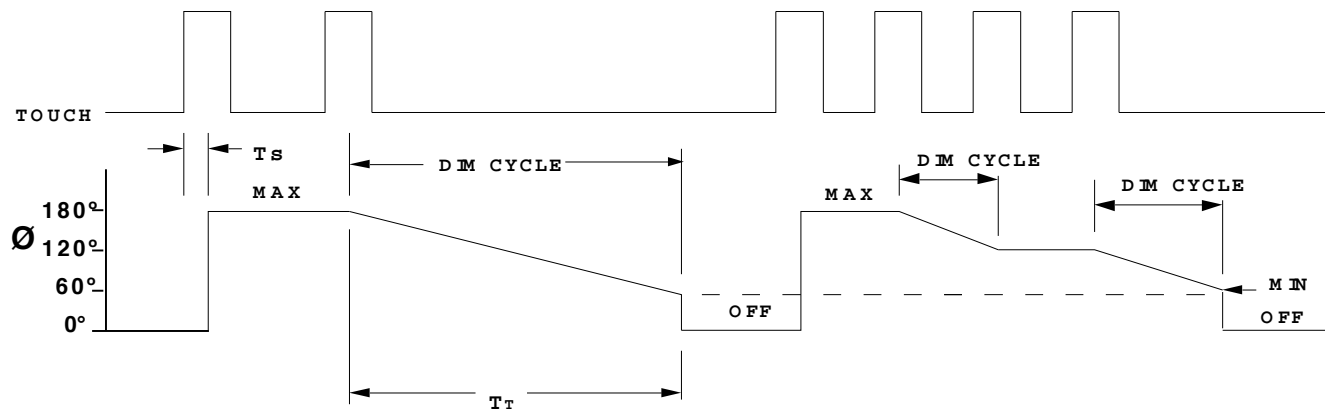
FIGURE 3. TOUCH vs TRIG/ CONDUCTION ANGLE, Ø

CLOCK | 1 → CLOCK GENERATOR

SYNC | 2 → ZERO CROSS DETECT

TOUCH | 4 →
CONTROL | 5 → AGC TOUCH CONTROL

RAMP | 6 → BRIGHTNESS CONTROL

TRIGGER GENERATOR → 8 | TRIG/

V$_{DD}$ | 3 → V+

V$_{SS}$ | 7 → GND
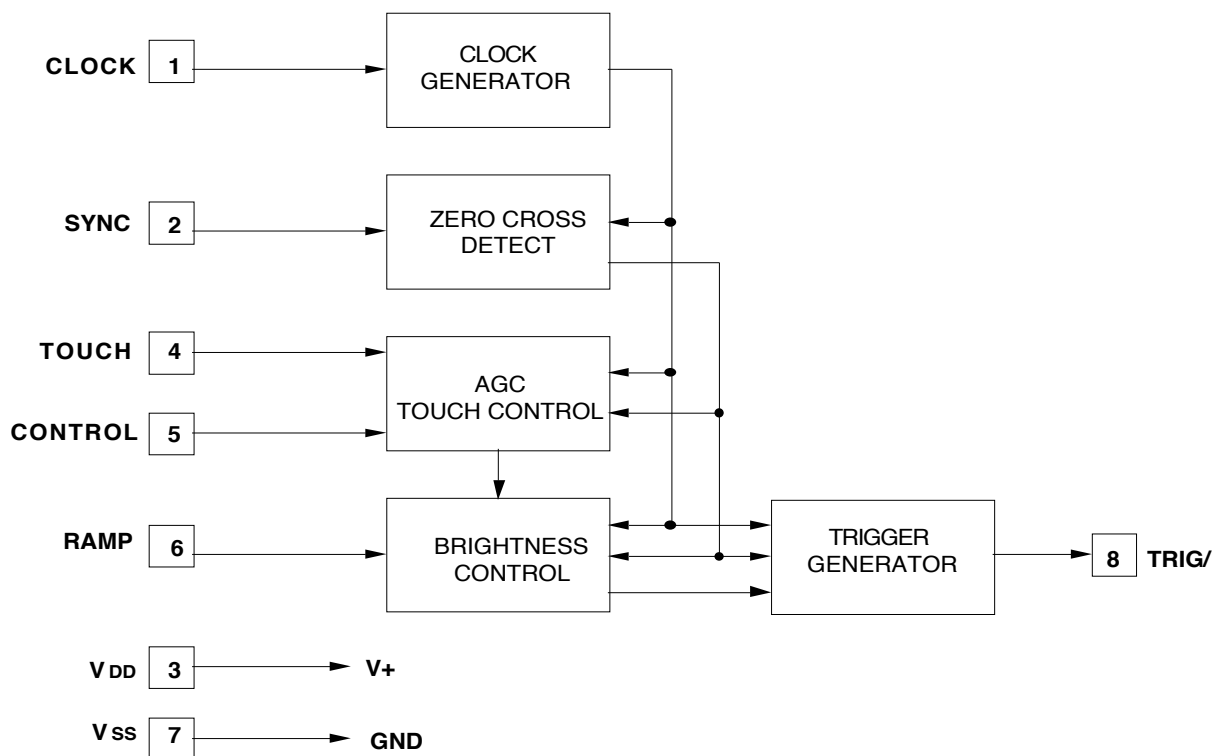
FIGURE 4. LS7540 BLOCK DIAGRAM

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FIGURE 5. TOUCH LAMP APPLICATION SCHEMATIC

+V

LOAD

R1   D1

MT2   T1

MT1   G

C1 +

R5   + C6 −

AC MAINS

Z1

R6

−V

R7   C5   C7

C2

8   7   6   5

TRIG/   VSS   RAMP   CONT

C8* (SEE NOTE 2)

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CLOCK   SYNC   VDD   TOUCH

1   2   3   4

R2

R4

D2   D3

TOUCH PLATE (LAMP BODY)

C3   C4   R3
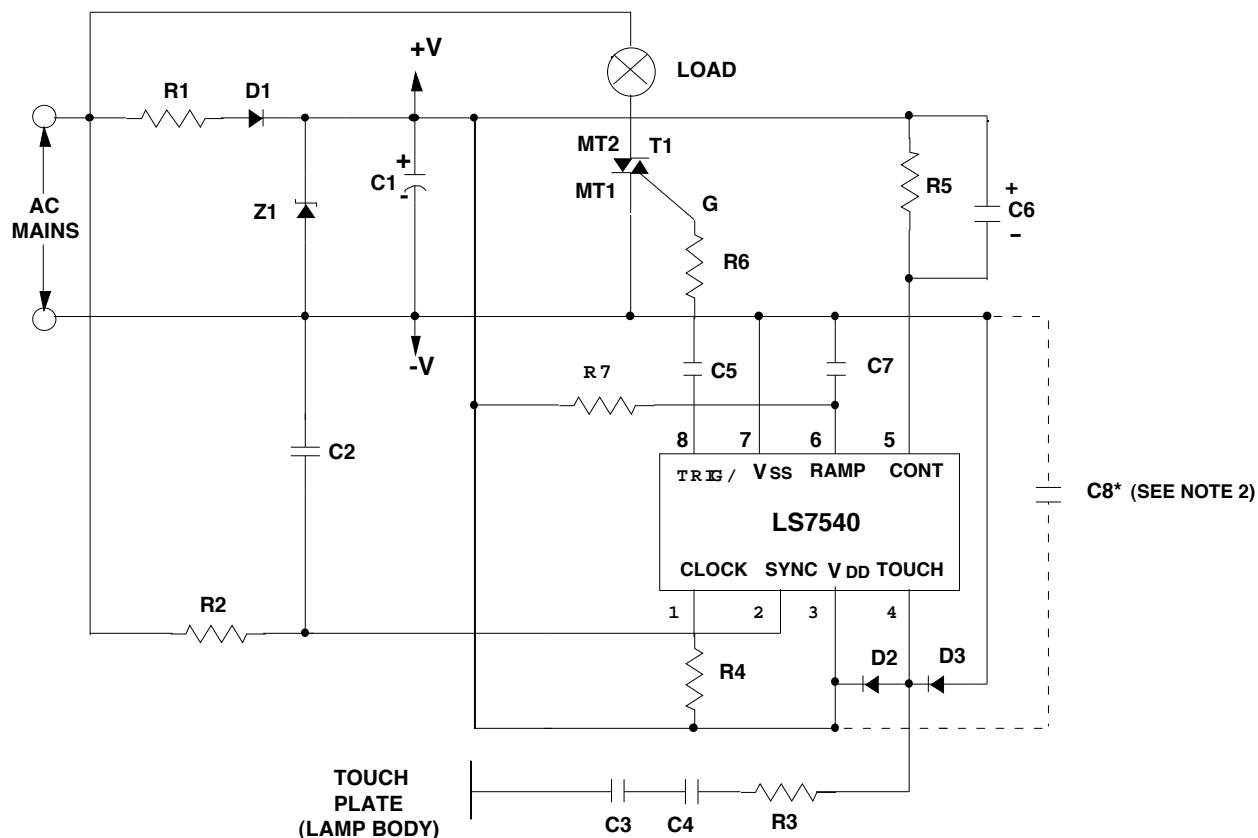
115VAC APPLICATION

R1 = 20kΩ, 1W
R2 = 470kΩ, 1/4W
R3 = 1kΩ, 1/4W
(**1**) R4 = 350kΩ, 1/4W,1%
R5 = 10MΩ, 1/4W
R6 = 100Ω, 1/4W
R7 = See Note 1
C1 = 47μF, 16V
C2 = 1000pF, 16V
C3 = 1000pF, 1kV

C4 = 1000pF, 1kV
C5 = 0.03μF, 16V (only for Figure 5)
C6 = 1μF, 16V
C7 = See Note 1
Z1 = 5.1V, 1/4W Zener
D1 = 1N4004
D2 = 1N4148
D3 = 1N4148
T1 = Q2004L4 (Typical Triac)
   or Q2004F41 (Typical Triac)

220VAC APPLICATION

R1 = 39kΩ, 2W
R2 = 910kΩ, 1/4W
(**1**) R4 = 420kΩ, 1/4W, 1%
D1 = 1N4005
T1 = Q4004L4 (Typical Triac)
   or Q4004F41 (Typical Triac)

All other values remain the same.

(**1**) Resistor should be placed adjacent to Pin 1.

NOTE 1: See RAMP input description for determining values for R7 and C7.

NOTE 2: A good PCB layout using through-hole components will provide protection for ESD introduced at the Touch Plate in the range of 25kV. Using surface mount components and/or a poor PCB layout can reduce the ESD protection. The OEM can increase the ESD protection provided by the product with any combination of the following steps:

Step 1: The most effective and least costly way to increase ESD protection is to create a spark gap around the Touch Plate input on the PCB. This will increase ESD protection on a good PCB layout to abut 35kV. The gap should be made with a split metal ring with each side of the metal ring connected back to opposite sides of the AC line. This ensures that a path for the spark back to house ground through AC Neutral exists independent of line plug polarity. The split ring and the center conduction plate should be constructed so that the spacing between them conforms to UL requirements. The spark gap will absorb most of the ESD leaving a remnant of about 10kV for the rest of the circuit to absorb.

Step 2: Increase R3 from 1kΩ to 5.1kΩ and add C8, a 0.1μF capacitor, between VDD and Vss. (A minimal loss in touch sensitivity may be experienced.)

Step 3: Replace diodes D2 and D3 (1N4148) with Schottky diodes (1N5819 or similar)

FIGURE 6. TOUCH LAMP APPLICATION SCHEMATIC
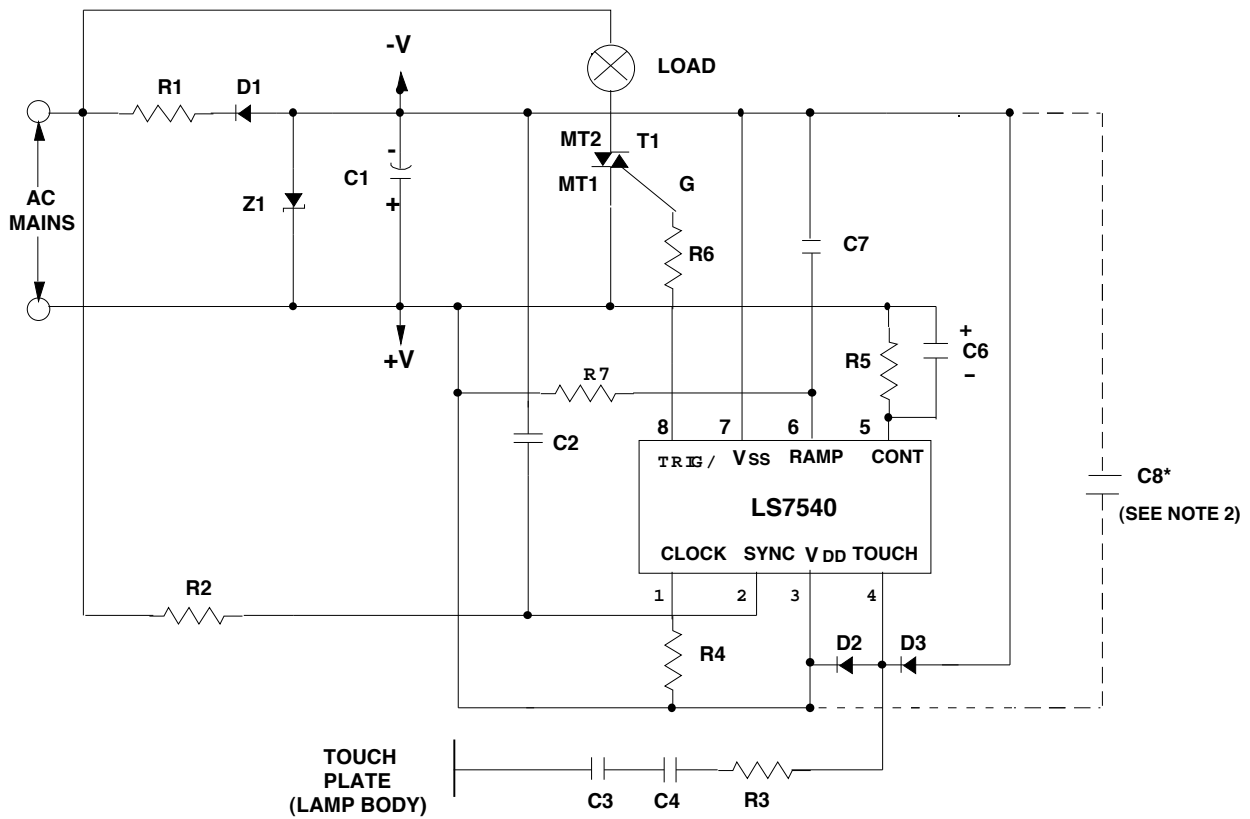
The Figure 6 Application Schematic functions identically to that shown in Figure 5 with one less component. Referencing Triac T1 to the +V power supply of the IC eliminates the need to AC couple the TRIAC/ pulse to the Triac Gate thereby eliminating component C5.
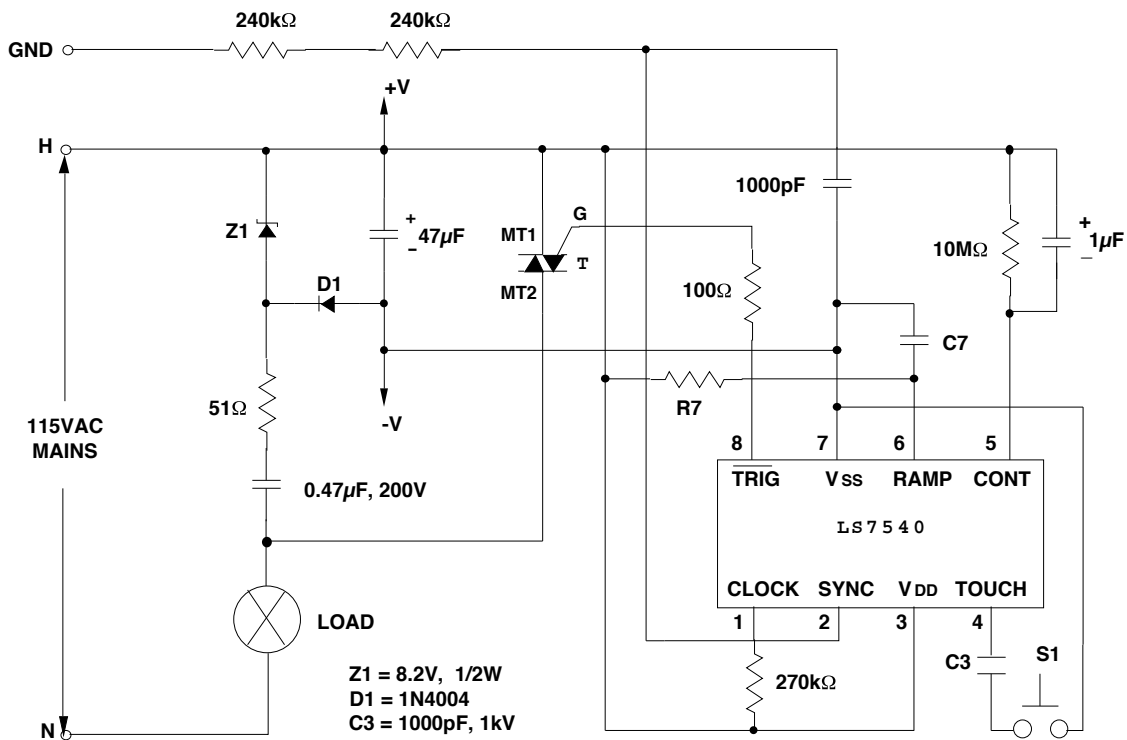
FIGURE 7. PUSHBUTTON APPLICATION SCHEMATIC
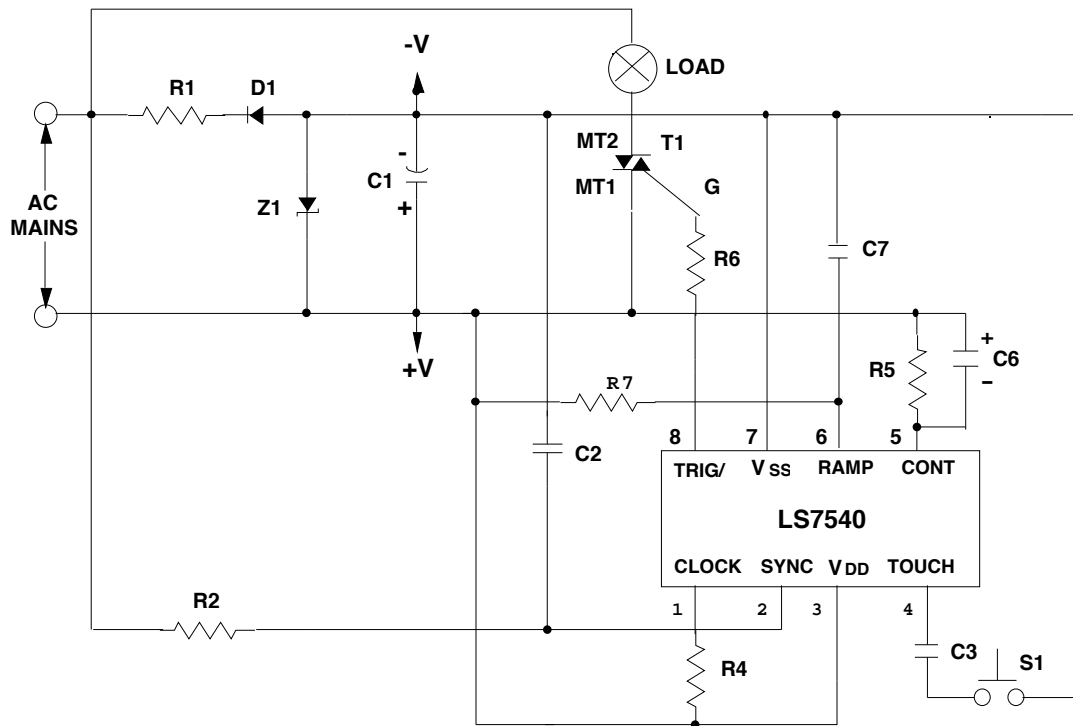
Using the Figure 6 schematic as an example, components R3, C4, C7, D1 and D2 are eliminated and Pushbutton Switch, S1, is connected from one end of C3 to Vss. Each depression of S1 causes the Brightness Level to change in the same way as a Touch does in Figure 6.

FIGURE 8. A Touch Wall Switch Using the LS7540 IC.

FIGURE 9. A Pushbutton Wall Switch Using the LS7540 IC.