LSI/CSI

LS7232ND

TOUCH CONTROL LAMP DIMMER

January 2003

FEATURES:
- Phase-lock loop synchronization allows use in Wall Switch applications.
- Provides brightness control of incandescent lamps with touch plates or pushbutton switches.
- Controls the duty cycle from 23% to 88% (conduction angles for AC half-cycles between 41° and 158°, respectively.)
- Operates at 50Hz/60Hz line frequency.
- Extension input for remote activation.
- +12V to +18V Power Supply voltage (V_{SS} - V_{DD}).
- LS7232ND (DIP); LS7232ND-S (SOIC) - See Figure 1

DESCRIPTION:
LS7232ND is a MOS integrated circuit designed to control brightness of incandescent lamps. The output of this IC controls the brightness of a lamp by controlling the firing angle of a triac connected in series with the lamp. All internal timings are synchronized with the line frequency by means of a built-in phase-lock loop circuit. The output occurs once every half-cycle of the line frequency. Within the half-cycle, the output can be positioned anywhere between 158° conduction angle for maximum brightness and 41° conduction angle for minimum brightness in relation to the AC line frequency. The positioning of the output is controlled by applying a low level at the $\overline{SENS}$ input or a high level at the EXT input.

These functions may be implemented with very few interface components, as shown in Figure 5. When implemented in this manner, touching of the Touch Plate causes the lamp brightness to change as follows:

1. If the Touch Plate is touched momentarily (42ms to 333ms), the lamp is:
   a) turned off if it was on,
   b) turned on if it was off.
   The brightness resulting is either full brightness or, depending on the mode, a previous brightness stored in the IC memory.

2. If the Touch Plate is touched for a prolonged time (more than 342ms) the light intensity changes slowly. As long as the touch is maintained, the change continues; the direction of change reverses whenever the maximum or minimum brightness is reached.

INPUT/OUTPUT DESCRIPTION:
V_{SS} (Pin 1)
Supply voltage positive terminal.

MODE (Pin 2)
The LS7232ND can operate in either of 3 modes, Mode 0, Mode 1 or Mode 2. A full description of the operating modes is provided in Table 1. The MODE input level selects the operating mode as follows:
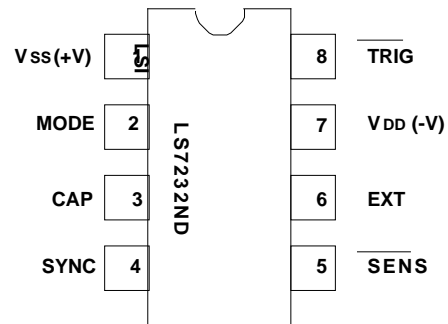
PIN ASSIGNMENT - TOP VIEW

$V_{SS}(+V)$	1		8	TRIG
MODE	2	LS7232ND	7	V_{DD} (-V)
CAP	3		6	EXT
SYNC	4		5	$\overline{SENS}$

FIGURE 1

MODE Input	Mode	Functional Equivalent*
V_{DD}	0	LS7231
V_{SS}	1	LS7232
Float	2	LS7233

*NOTE: The LS7232ND can replace LS7231, LS7232 and LS7233 where the DOZE input is not used. The LS7232 PCB requires no change. The LS7233 PCB requires that the Pin 2 connection be opened. The LS7231 PCB requires that the Pin 2 connection be made to V_{DD} instead of V_{SS}.

CAP (Pin 3)
The CAP input is for the PLL filter capacitor.
A 0.047µF capacitor should be connected to this input.

SYNC (Pin 4)
The AC Line Frequency is applied to this input through an external RC circuit (See Figure 5). The Phase-Lock Loop in the IC synchronizes all internal timings to the AC signal at the SYNC input.

$\overline{SENS}$ (Pin 5)
A low level activates this input (See Table 1) which controls the turn-on, turn-off and conduction angle, Ø (See Figure 3), of the TRIG signal with respect to the SYNC input.

EXT (Pin 6)
The EXT input is functionally identical to the $\overline{SENS}$ input except that a high level activates this input. It is recommended that the EXT input be used instead of the $\overline{SENS}$ input when long extension wires are employed between the IC and the Sensing Circuitry (See Figure 5 and Figure 6) because the EXT input is less susceptible to noise.

7232ND-012703-1

The functional differences of the modes of the LS7232ND are explained
in Table 1 and the $\overline{\text{TRIG}}$ output conduction angle diagrams in Figure 4.

TABLE 1

MODE	TOUCH TYPE				DIMMING DIRECTION REVERSAL (Note 3)
	SHORT (T$_{S1}$ Duration)		**LONG (T$_{S2}$ Duration)**		
	PRE-TOUCH Ø	POST-TOUCH Ø	PRE-TOUCH Ø	POST-TOUCH Ø	
0 **(LS7231)**	Off Max Intermediate	Max Off Off	Off Max Intermediate	Starts varying at Min Starts varying at Max Starts varying at Pre-Touch brightness	N/A N/A NO
1 **(LS7232)**	Off Max Intermediate	Memory (Note 1) Off Off	Off Max Intermediate	Starts varying at Memory (Note 2) Starts varying at Max Starts varying at Pre-Touch brightness	YES N/A YES
2 **(LS7233)**	Off Max Intermediate	Max Off Off	Off Max Intermediate	Starts varying at Min Starts varying at Max Starts varying at Pre-Touch brightness	N/A N/A YES

NOTE 1: "Memory" refers to the conduction angle, Ø, which existed prior to the current off-state.
First time after power-up, the Memory value defaults to maximum conduction angle.
NOTE 2: First time after power-up, LONG touch causes intensity to vary starting at minimum conduction angle.
NOTE 3: NO = Dimming direction does not reverse from prior dimming direction.
YES = Dimming direction does reverse from prior dimming direction.
N/A = Does not apply

V$_{DD}$ (Pin 7)
Supply voltage negative terminal.

$\overline{\text{TRIG}}$ (Pin 8)
The $\overline{\text{TRIG}}$ output is a low level pulse occurring once every half-cycle of the SYNC input. The conduction angle, Ø, of the output in relation to the SYNC signal controls the lamp brightness.

In continuous dimming operation (i.e. when the $\overline{\text{SENS}}$ input is continuously held low) the $\overline{\text{TRIG}}$ conduction angle, Ø, sweeps up and down between 41˚ and 158˚ continuously. The time vs Ø curve is not linear (See Figure 4). Between two maxima on this curve, there are 4 discontinuous points labeled A1, B1, B2, A2.

The discontinuities are as follows:

1. From maximum to A1. In this region, Ø is changed by equal increments (ø) for every 2 SYNC clocks.
2. From A1 to B1. In this region, the increments (ø) take place for every 4 SYNC clocks.
3. From B1 to B2. In this region Ø is held at a constant level (ø = 0).
4. From B2 to A2. Same as 2.
5. From A2 to Max. Same as 1.

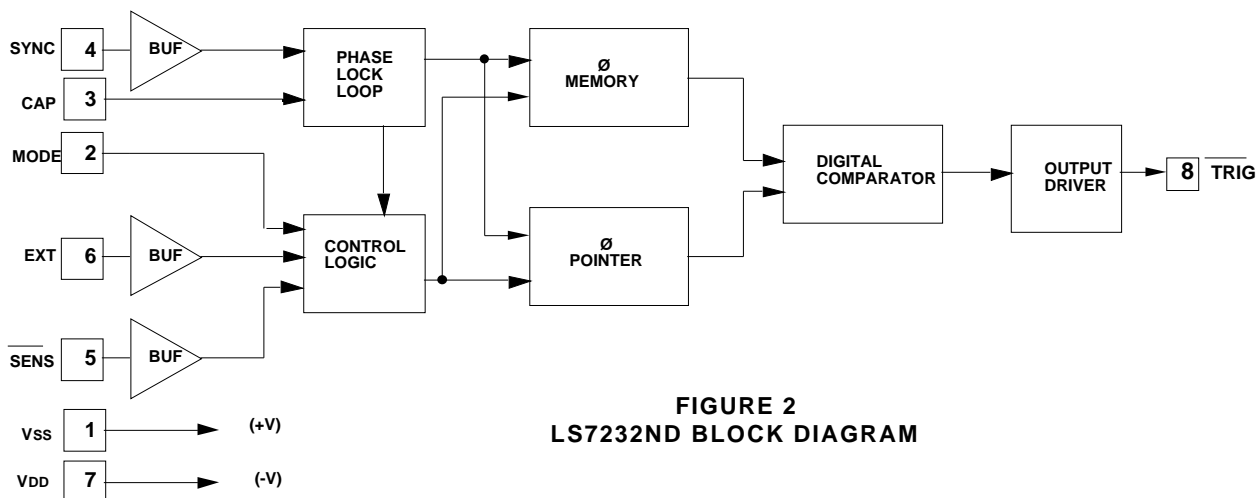The slower rate of change in ø over A1B1B2A2 region is to accommodate for eye adjustment at lower light intensity.

FIGURE 2
LS7232ND BLOCK DIAGRAM

7232ND-012703-2

ABSOLUTE MAXIMUM RATINGS:

PARAMETER	SYMBOL	VALUE	UNIT
DC Supply Voltage	V_{SS}	+20	V
Any Input Voltage	V_{IN}	V_{SS} - 20 to V_{SS} + 0.5	V
Operating Temperature	T_A	0 to +80	˚C
Storage Temperature	T_{STG}	-65 to +150	˚C

DC ELECTRICAL CHARACTERISTICS: (T_A = 25˚C, all voltages referenced to V_{DD})

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	CONDITION
Supply Voltage	V_{SS}	+12	–	+18	V	-
Supply Current	I_{SS}	–	1.0	1.4	mA	V_{SS} = +15V, output off
Input Voltages:						
SYNC Lo	V_{IRL}	0	–	V_{SS} - 9.5	V	-
SYNC Hi	V_{IRH}	V_{SS} - 5.5	–	V_{SS}	V	-
SENS Lo	V_{IOL}	0	–	V_{SS} - 8	V	-
SENS Hi	V_{IOH}	V_{SS} - 2	–	V_{SS}	V	-
EXT Lo	V_{IVL}	0	–	V_{SS} - 8	V	-
EXT Hi	V_{IVH}	V_{SS} - 2	–	V_{SS}	V	-
Input Current:						
SYNC, **SENS**, EXT Hi	I_{IH}	–	–	110	µA	With Series 1.5M Resistor to AC Line
SYNC, **SENS**, EXT Lo	I_{IL}	–	–	100	nA	-
TRIG Hi Voltage	V_{OH}	–	V_{SS}	–	V	-
TRIG Lo Voltage	V_{OL}	–	V_{SS} - 8	–	V	V_{SS} = +15V
TRIG Sink Current	I_{OS}	25	–	–	mA	V_{SS} = +15V V_{OL} = V_{SS} - 4V

TIMING CHARACTERISTICS (See Figures 2 and 3):

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

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
SYNC Frequency	fs	40	-	70	Hz
SHORT TOUCH (ON/OFF Operation)	T_{S1}	42	-	333	ms
LONG TOUCH (Dimming Operation)	T_{S2}	342	-	infinite	ms
TRIG Pulse Width	T_W	-	33	-	µs
TRIG Conduction-Angle (See Note 1)	Ø	41	-	158	deg
Ø Period (Max to Max in continuous dimming)	-	-	7.64	-	sec
A1B1 = B2A2 duration	-	-	934	-	ms
B1B2 Min. intensity dwell	-	-	500	-	ms

NOTE 1.

In the circuit schematic shown in Figure 5, the SYNC input signal is delayed in phase with respect to the AC Line by about 7°. This delay reduces the conduction angle, Ø, with respect to the AC Line by 7° from the values shown above.
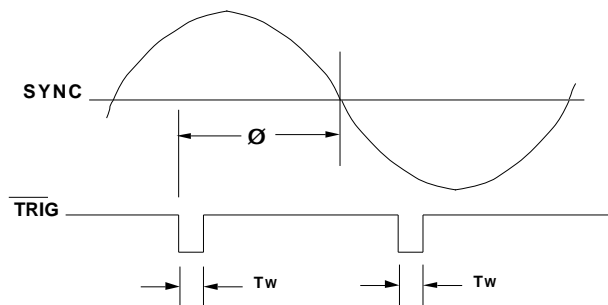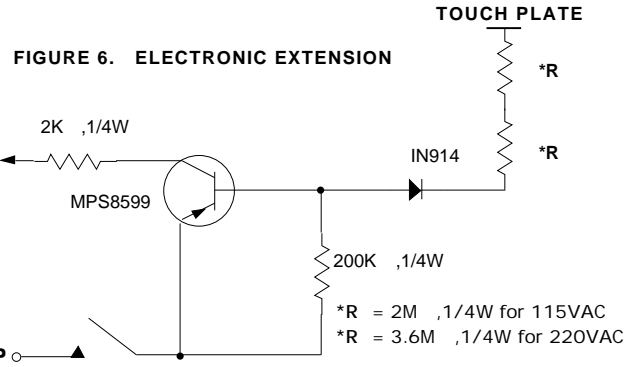

FIGURE 3. TRIG OUTPUT CONDUCTION ANGLE, Ø

7232ND-012703-3

APPLICATION EXAMPLE:

A typical implementation of a lamp dimmer circuit is shown in Fig. 5. Here the brightness of the lamp is set by touching the Touch Plate. The functions of different components are as follows:

- The 15V DC supply for the chip is provided by Z, D1, R1, C2 and C5.
- R2 and C4 generate the filtered signal for the SYNC input for synchronizing the internal PLL with the line frequency.
- R3 and C7 act as a filter circuit for the electronic extension. If extensions are not used, the EXT input (Pin 6) should be tied to V_{DD} (Pin 7).
- R4, R5, R6 set up the sensitivity of the $\overline{SENS}$ input. C6 provides noise filtering.
- C3 is the filter capacitor for the internal PLL.
- R8 provides current limiting and isolation between the chip output and the triac gate.
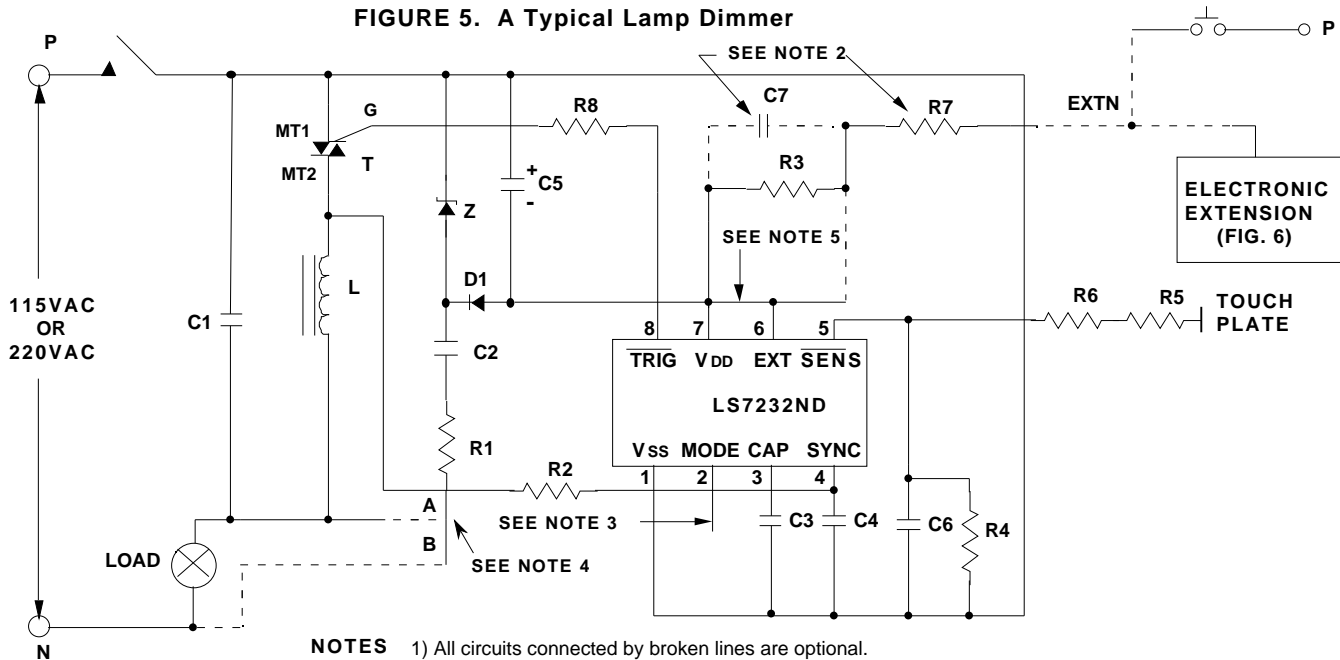- C1 and L are RF filter circuits.

In the case of momentary power failure, the circuit state remains unchanged for a period of up to 1 sec. For longer power interruptions, the output is shut off.

FIGURE 6. ELECTRONIC EXTENSION

TOUCH PLATE

*R

2K ,1/4W

EXTN

MPS8599

IN914

*R

200K ,1/4W

*R = 2M ,1/4W for 115VAC
*R = 3.6M ,1/4W for 220VAC

P

EXTENSIONS:

All switching and dimming functions can be implemented by utilizing the EXT input. This can be done by either a pushbutton switch or the electronic switch in conjunction with a Touch Plate, shown in Figure 6. When the plate is touched, a logic high level is generated at the EXT input of the IC for both half-cycles of the line frequency. (See Figure 5)

FIGURE 5. A Typical Lamp Dimmer

P

SEE NOTE 2

P

C7

R8

R7

EXTN

G

MT1

MT2

T

+C5
-

R3

SEE NOTE 5

ELECTRONIC EXTENSION (FIG. 6)

Z

D1

R6   R5   TOUCH PLATE

115VAC OR 220VAC

C1

L

| 8 | 7 | 6 | 5 |

$\overline{TRIG}$ V_{DD} EXT $\overline{SENS}$

LS7232ND

V_{SS} MODE CAP SYNC

| 1 | 2 | 3 | 4 |

C2

R1

R2   SEE NOTE 3

A
B   SEE NOTE 4

LOAD

N

C3 C4   C6 R4

NOTES

1) All circuits connected by broken lines are optional.
2) C7 is used only with electronic extension and R7 is used only with mechanical switch.
3) See I/O Description for MODE (Pin 2)
4) Use Connection A when Neutral is not available. Use Connection B when Neutral is available.
5) Connection between Pin 6 & Pin 7 should be broken when EXT is used.

115V

C1 = 0.15µF, 200V	R4 = 1M to 5M , 1/4W
(1) C2 = 0.33µF, 200V	(Select for sensitivity)
C3 = 0.047µF, 25V	R5, R6 = 2.7M , 1/4W
C4 = 470pF, 25V	R7 = 150k , 1/4W
C5 = 47µF, 25V	R8 = 100 , 1/4W
C6 = 680pF, 25V	D1 = IN4148
C7 = 0.1µF, 25V	Z = 15V, 1W (Zener)
(2) R1 = 270 , 1W	T = Q4006L4 Triac (Typical)
R2 = 1.5M , 1/4W	L = 100µH (RFI Filter)
R3 = 1.5M , 1/4W	

(1) For Connection A. Use 0.22µF for Connection B.
(2) For Connection A. Use 1/4W for Connection B.

220V

C1 = 0.15µF, 400V	R4 = 1M to 5M , 1/4W
(3) C2 = 0.22µF, 400V	(Select for sensitivity)
C3 = 0.047µF, 25V	R5, R6 = 4.7M , 1/4W
C4 = 470pF, 25V	R7 = 150k , 1/4W
C5 = 47µF, 25V	R8 = 100 , 1/4W
C6 = 680pF, 25V	D1 = 1N4148
C7 = 0.1µF, 25V	Z = 15V, 1W (Zener)
(4) R1 = 1k , 2W	T = Q5004L4 Triac (Typical)
R2 = 1.5M , 1/4W	L = 200µH (RFI Filter)
R3 = 1.5M , 1/4W	

(3) For Connection A. Use 0.1µF for Connection B.
(4) For Connection A. Use 1/4W for Connection B.

7232ND-012703-4

FIGURE 7. A SWITCH-OPERATED LAMP DIMMER

AC ON-OFF SWITCH

PUSHBUTTON SWITCH

115VAC OR (SEE NOTE 1) **220VAC**

MT1 T1
MT2
G
R3
C5 +
-
Z1
D1
L
C2
R1
R2

8 7 6 5
TRIG V$_{DD}$ **EXT SENS**

LS7232ND

V$_{SS}$ **MODE CAP SYNC**
1 2 3 4

(SEE NOTE 2)

C3 C4 R4

C1

OUT TO LAMP
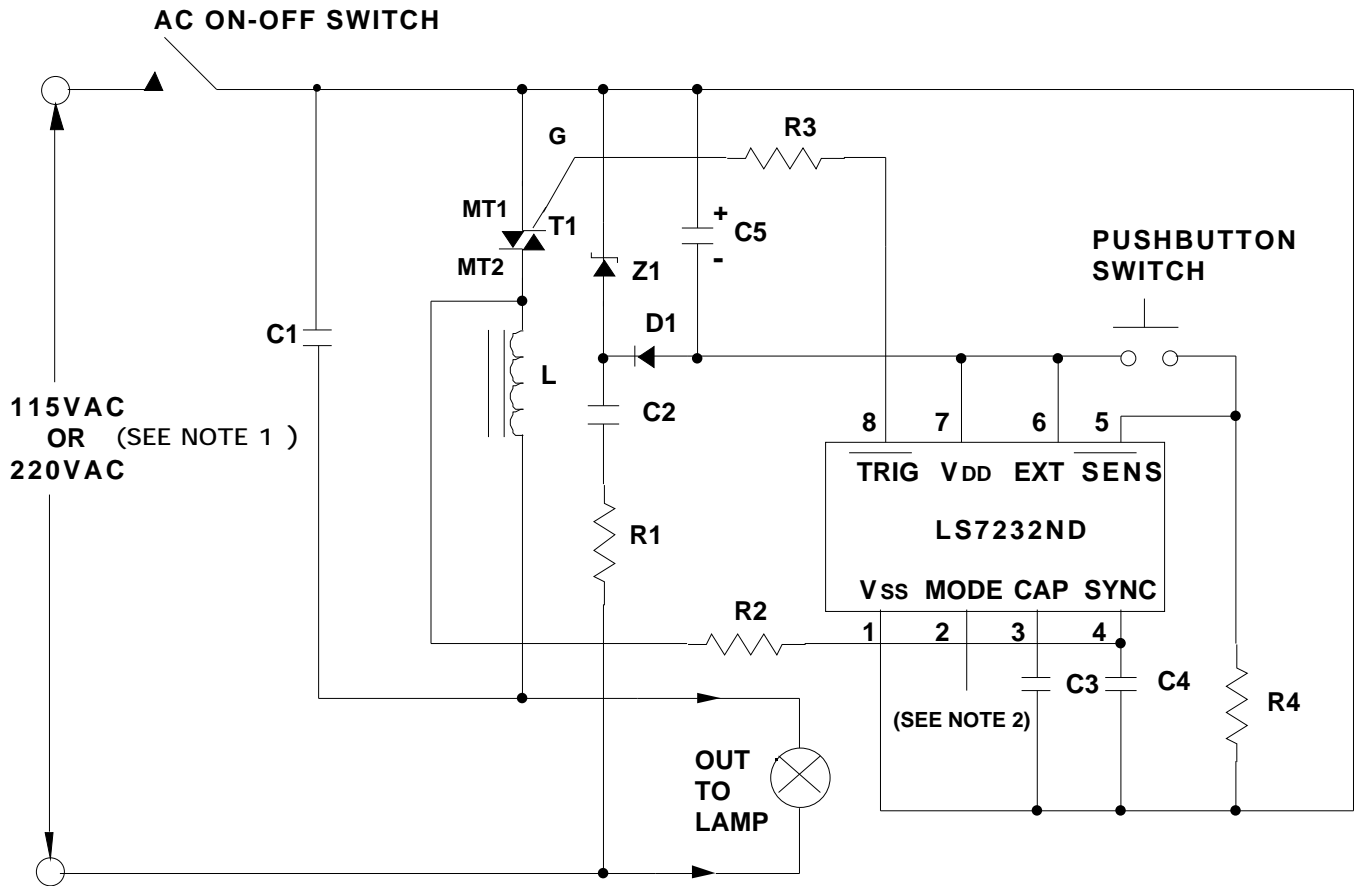
NOTE 1: Operation is independent of Line Plug Polarity
NOTE 2: See I/O Description for MODE (Pin 2)

115V	220V
C1 = 0.15µF, 200V	C1 = 0.15µF, 400V
C2 = 0.22µF, 200V	C2 = 0.1µF, 400V
C3 = 0.047µF, 25V	C3 = 0.047µF, 25V
C4 = 470pF, 25V	C4 = 470pF, 25V
C5 = 47µF, 25V	C5 = 47µF, 25V
R1 = 270 , 1/4W	R1 = 1k , 1/4W
R2 = 1.5M , 1/4W	R2 = 1.5M , 1/4W
R3 = 100 , 1/4W	R3 = 100 , 1/4W
R4 = 1M , 1/4W	R4 = 1M , 1/4W
D1 = IN4148	D1 = IN4148
Z1 = 15V, 1W (Zener)	Z1 = 15V, 1W (Zener)
T1 = Q4008L4 (Typical)	T1 = Q5004L4 (Typical)
L = 100µH (RFI Filter)	L = 200µH (RFI Filter)

APPLICATIONS:
1. Foot-Switch Dimmer for large floor lamps.
2. Hand-Switch Dimmer for end-table lamps.

The information included herein is believed to be accurate and reliable. However, LSI Computer Systems, Inc. assumes no responsibilities for inaccuracies, nor for any infringements of patent rights of others which may result from its use.

7232ND-012703-5