LDS8620

IXYS Display

200 mA, Dual Output LED Flash/Lamp Driver

FEATURES

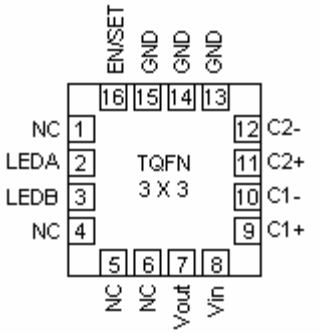
- **Multi-mode charge pump: 1-x, 1.5-x, 2-x**
- **Ultra low dropout PowerLite™ Current Regulator***
- **Drives two high-current LEDs up to 96 mA each**
- **1-wire LED current programming**
- **Power efficiency up to 95%**
- **Low noise input ripple in all modes**
- **Low current shutdown mode**
- **Soft start and current limiting**
- **Short circuit protection**
- **Thermal shutdown protection**
- **Tiny 3 x 3 x 0.8 mm 16-pin TQFN package**

APPLICATION

- **LED Light Supply for Smart Phones, PDAs, and Cell Phones**
- **LED Flashlights**
- **LED Flash/Strobe Applications**

DESCRIPTION

The LDS8620 is a high efficiency multi-mode fractional charge pump with ultra low feedback



voltage that can drive up to two high-current LEDs. The ultra low dropout PowerLite™ Current Regulator increases device's efficiency up to 95%.

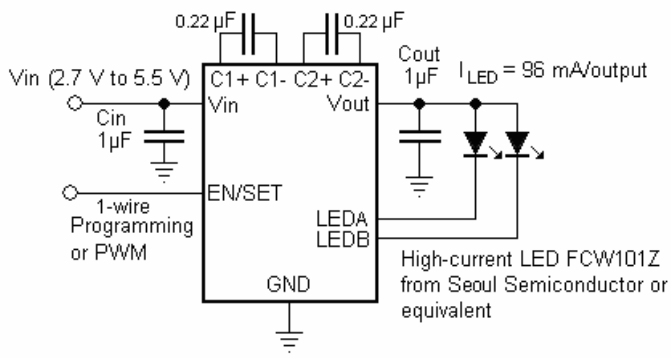
The EN/SET logic input functions as a chip enable and a current setting interface.

LED driver is programmable over a one wire digital interface from 1.5 to 96 mA in 1.5 mA steps. LEDs may be turned on/off or programmed separately

Low noise input ripple is achieved by operating at a constant switching frequency which allows the use of small external ceramic capacitors. The multi-fractional charge pump supports a wide range of input voltages from 2.7 V to 5.5 V.

The device is available in in 16-lead TQFN 3mm x 3mm package with a max height of 0.8 mm.

TYPICAL APPLICATION CIRCUIT



ABSOLUTE MAXIMUM RATINGS

Parameter	Rating	Unit
Vin, LEDx, C1±, C2± voltage	6	V
Vout voltage	6.5	V
EN/SET voltage	Vin + 0.7V	V
Storage Temperature Range	-65 to +160	°C
Junction Temperature Range	-40 to +125	°C
Soldering Temperature	300	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Rating	Unit
Vin	2.7 to 5.5	V
Ambient Temperature Range	-40 to +85	°C
I_{LED} per LED pin	0 to 96	mA
Total Output Current (I_{LEDA} + I_{LEDB})	0 to 192	mA

Typical application circuit with external components is shown on page 1.

ELECTRICAL OPERATING CHARACTERISTICS

(Over recommended operating conditions unless specified otherwise): Vin = 3.6V, Cin = Cout = 1µF, C1 = C2 = 0.22 µF, EN = High, T_{AMB} = 25°C

Name			Conditions	Min	Typ	Max	Units
Quiescent Current			1-x mode		1.5		mA
			1.5-x mode		4.5		
			2-x mode		5.5		
Shutdown Current			V_{EN} = 0V			1	µA
LED Current Accuracy			1.5 mA ≤ $I_{LEDA,B}$ ≤ 96 mA		±3		%
LED Channel Matching			(I_{LED} - I_{LEDAVG}) / I_{LEDAVG}		±3		%
Output Resistance (open loop)			1-x mode		0.7		Ω
			1.5-x mode, Vin = 2.9 V		5.5		
			2-x mode, Vin = 2.7 V		6.5		
Charge Pump Frequency					1.1		MHz
Output short circuit Current Limit			Vout < 0.5V		35		mA
Input Current Limit			Vout > 1V		450		mA
1-x to 1.5-x, or 1.5-x to 2-x Transition Thresholds at any LED pin			$I_{LEDA,B}$ = 60 mA		50		mV
1.5-x to 1-x Mode Transition Hysteresis					600		mV
Transition Filter Delay					800		µs
EN/SET Pin	Input Leakage			-1		1	µA
	Logic Level	High		1.3			V
		Low				0.4	
Thermal Shutdown, T_{SD}					150		°C
Thermal Hysteresis, T_{SD_HS}					20		
Under Voltage Lockout (UVLO)					2.1		V
Over Voltage Protection						6.2	V

RECOMMENDED EN/SET TIMING

For 2.5 ≤ VIN ≤ 5.5V, over full ambient temperature range -40 to +85ºC.

Symbol	Name	Conditions	Min	Typ	Max	Units
t_{SETUP}	EN/SET setup from shutdown		10		100	µs
t_{LO}	EN/SET program low time		0.2		100	µs
t_{HI}	EN/SET program high time		0.2		100	µs
t_{OFF}	EN/SET low time to shutdown		1.5			ms
$t_{DATADELAY}$	EN/SET Delay to DATA		500			µs
$t_{RESETDELAY}$	EN/SET Delay High to ADDRESS		2			ms

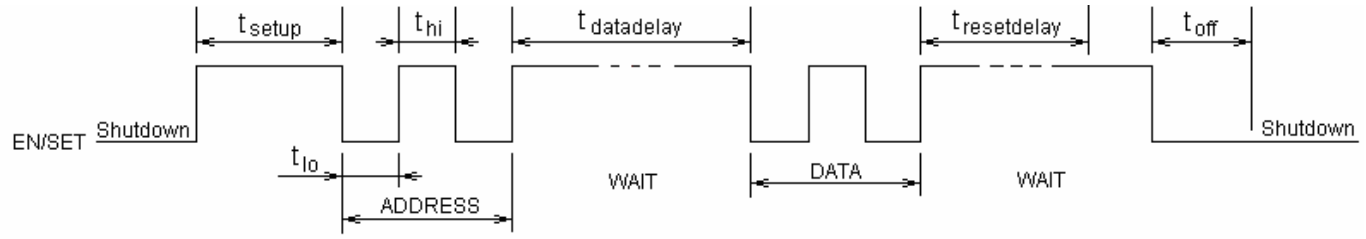


Figure 1. EN/SET One Wire Addressable Timing Diagram

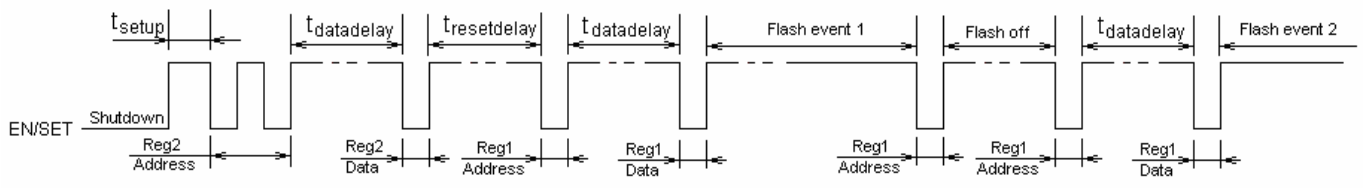


Figure 2. EN/SET multi flash timing diagram (see description at p.8)

REGISTER CONFIGURATION AND PROGRAMMING

Table 1. Register Address and Data

Register	Address Pulses	Description	Bits	DATA pattern	
				Bit 1	Bit 0
REG1	1	Output Configuration	2	LED B Enable	LED A Enable
REG2	2	Global Current Setting*	6	See Table 3 for values	
REG3	3	LED A Current Setting	6		
REG4	4	LED B Current Setting	6		
REG5	6	Return Lockout	1		RTLKO

Note: *) If Global current setting register Reg2 is used, registers Reg3 and Reg4 should be empty, and vice versa If registers Reg3and Reg4 are used, Reg2 should be empty to prevent data interference.

Table 2. Reg1 Code

Data pulses	Reg1 Bit		LED state	
	1	0	LED B	LED A
0	0	0	Off	Off
1	1	1	On	On
2	1	0	On	Off
3	0	1	Of	On

Note: If bits Bit0 – Bit1 are set to zero, the corresponding LED bank is disabled.

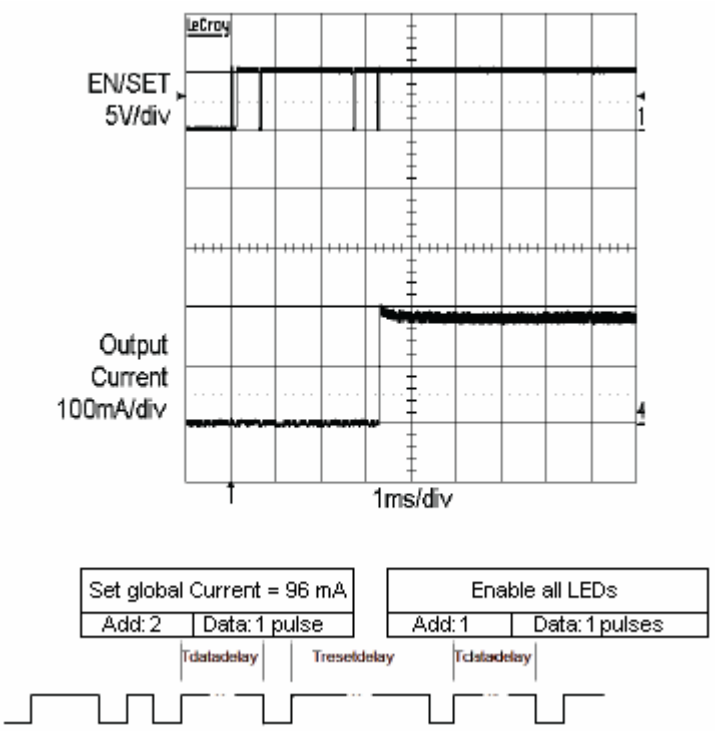
Table 3. REG2-4 Current Setting Registers

Data Pulses	Reg2-4 value (binary)	LED Current, mA
0	000000	1.5
1	111111	96
2	111110	94.5
3	111101	93
4	111100	91.5
5	111011	90
6	111010	88.5
7	111001	87
8	111000	85.5
9	110111	84
10	110110	82.5
11	110101	81
12	110100	79.5
13	110011	78
14	110010	76.5
15	110001	75
16	110000	73.5
17	101111	72
18	101110	70.5
19	101101	69
20	101100	67.5
21	101011	66
22	101010	64.5
23	101001	63
24	101000	61.5
25	100111	60
26	100110	58.5
27	100101	57
28	100100	55.5
29	100011	54
30	100010	52.5
31	100001	51
32	100000	49.5

Data Pulses	Reg2-4 value (binary)	LED Current, mA
33	011111	48
34	011110	46.5
35	011101	45
36	011100	43.5
37	011011	42
38	011010	40.5
39	011001	39
40	011000	37.5
41	010111	36
42	010110	34.5
43	010101	33
44	010100	31.5
45	010011	30
46	010010	28.5
47	010001	27
48	010000	25.5
49	001111	24
50	001110	22.5
51	001101	21
52	001100	19.5
53	001011	18
54	001010	16.5
55	001001	15
56	001000	13.5
57	000111	12
58	000110	10.5
59	000101	9
60	000100	7.5
61	000011	6
62	000010	4.5
63	000001	3
64	000000	1.5

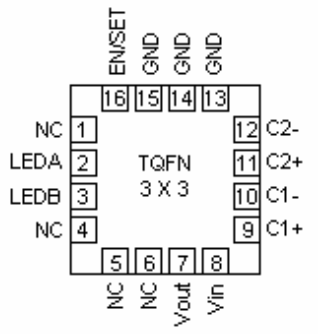
PROGRAMMING EXAMPLES

Programming 2 LEDs to 96 mA/output



PIN DESCRIPTION

Pin #	Name	Function
1	NC	No connect
2	LEDA	LED A cathode terminal
3	LEDB	LED B cathode terminal
4 - 6	NC	No connect
7	V_{OUT}	Charge pump output connected to the LED anodes
8	V_{IN}	Charge pump input, connect to battery or supply
9	C1+	Bucket capacitor 1 Positive terminal
10	C1-	Bucket capacitor 1 Negative terminal
11	C2+	Bucket capacitor 2 Positive terminal
12	C2-	Bucket capacitor 2 Negative terminal
13 - 15	GND	Ground Reference, Connect all these pins to GND
16	EN/SET	Device enable (active high) and LED Current Dimming Control
PAD	PAD	Connect to GND on the PCB



Top view: TQFN 16-lead 3 X 3 mm

PIN FUNCTION

V_{IN} is the supply pin for the charge pump. A small 1µF ceramic bypass capacitor is required between the Vin pin and ground near the device. The operating input voltage range is from 2.7V to 5.5V. Whenever the input supply falls below the under-voltage threshold (2.1 V), all the LED channels are disabled and the device enters shutdown mode.

EN/SET is the enable and one wire addressable control logic input for all LED channels. Guaranteed levels of logic high and logic low are set at 1.3 V and 0.4 V respectively. When EN/SET is initially taken high, the device becomes enabled and all LED currents remain at 0 mA. To place the device into zero current mode, the EN/SET pin must be held low for more than 1.5 ms.

V_{OUT} is the charge pump output that is connected to the LED anodes. A small 1µF ceramic bypass capacitor is required between the Vout pin and ground near the device.

GND is the ground reference for the charge pump. The pin must be connected to the ground plane on the PCB.

C1+, C1- are connected to each side of the ceramic bucket capacitor C1

C2+, C2- are connected to each side of the ceramic bucket capacitor C2

LEDA and LEDB provide the internal regulated current source for each of the LED cathodes. These pins enter high-impedance zero current state whenever the device is in shutdown mode.

PAD is the exposed pad underneath the package. For best thermal performance, the pad should be soldered to the PCB and connected to the ground plane

BLOCK DIAGRAM

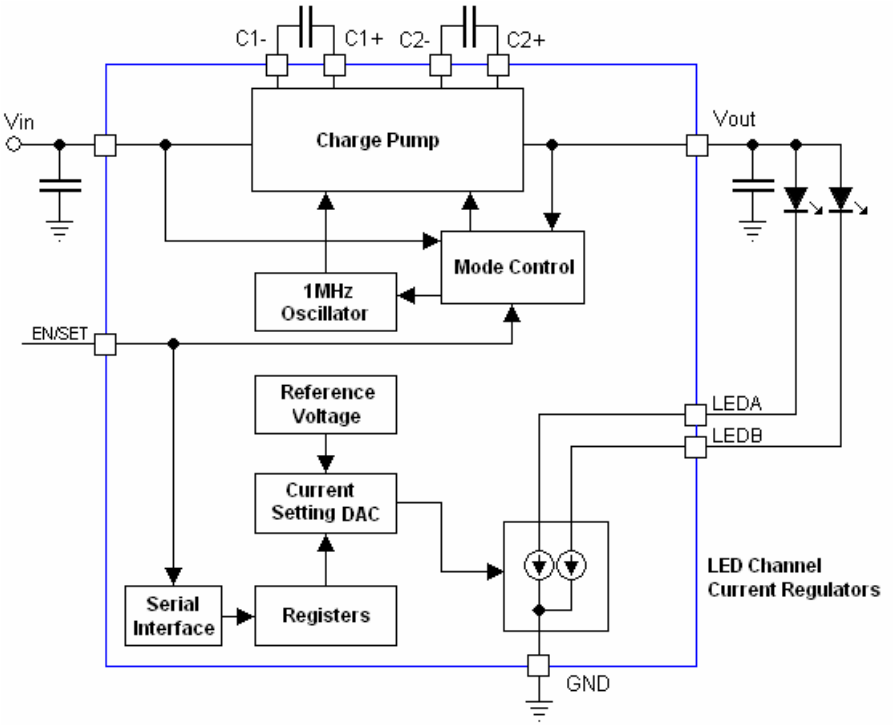


Figure 2. LDS8620 Functional Block Diagram

BASIC OPERATION

At power-up, EN/SET pin should be logic LOW. The LDS8620 starts operating in 1-x mode when EN/SET pin is asserted logic high and at least one channel is enabled. At 1-x mode, the output will be approximately equal to the input supply voltage (less any internal voltage losses). If the output voltage is sufficient to regulate all LED currents, the device remains in 1-x operating mode.

The low dropout PowerLite™ Current regulator (PCR) performs well at input voltages up to 50 mV above LED forward voltage significantly increasing driver's efficiency. The LDS8620 monitors voltage drop Vd across PCR at every channel in ON state. If this voltage falls below 50 mV (typical) at any one channel, (channel with LED with highest forward voltage), the Mode Control Block changes charge pump mode to the next multiplication ratio.

$Vd = V_{IN} \times M - V_F - Rcp \times Iout$, where Rcp is a Charge Pump Output Resistance at given mode, Iout is sum of all LED currents, and M is a charge pump' multiplication ratio.

If the input voltage is insufficient or falls to a level where Vd ≤ 50 mV, and the regulated currents cannot be maintained, the low dropout PowerLite™ Current Regulator switches the charge pump into 1.5-x mode (after a fixed delay time of about 800 µs). In 1.5-x mode, the charge pump' output voltage is approximately equal to 1.5 times the input supply voltage (less any internal voltage losses).

This sequence repeats at every mode until driver enters the 2-x mode.

If the device detects a sufficient input voltage is present to drive all LED currents in 1-x mode, it will change automatically back to 1-x mode. This only applies for changing back to the 1-x mode. The difference between the input voltage when exiting 1-x mode and returning to 1-x mode is called the 1-x mode transition hysteresis (about 600 mV).

LED Current Setting

The current in each of the LED is programmed through the 1-wire EN/SET digital control input. By pulsing this signal according to a IXYS 1-wire protocol, a set of internal registers can be addressed and written into allowing to configure each of LEDs with the desired current. There are five registers: the first is 2 bits long, while registers 2 – 4 are six bits long, and the fifth is one bit long. The registers are

programmed by first selecting the register address and then programming data into that register.

An internal counter records the number of falling edges to identify the address and data. The address is serially programmed adhering to low and high duration time delays. One down pulse corresponds to register 1 being selected. Two down pulses correspond to register 2 being selected and so on up to register 5. t_{LO} and t_{HI} must be within 200ns to 100µs. Anything below 200ns may be ignored.

Once the final rising edge of the address pointer is programmed, the user must wait longer than 500 µs before programming the first data pulse. Any falling edge after that will be recognised as a first data pulse.

Data in a register is reset once it is selected by the address pointer. If a register is selected but no data is programmed, the next pulse sequence will be recognized as data only. Do not select register without data sending because it may disrupt normal device operation.

Once the final rising edge of the data pulses is programmed, the user must wait at least 2 ms before programming another address. If programming fails or is interrupted, the user must wait $t_{RESETDELAY}$ 2 ms from the last rising edge before reprogramming can commence.

Upon EN/SET pin goes high, the LDS8620 automatically seeks an address instruction. The device requires a minimum 10 µs delay to ensure the initialization of the internal logic at power-up. After this time delay, EN/SET pin may be set high and the device registers may be programmed adhering to the timing constraints shown in Figure 1.

Register REG1 allows select the LEDs to be turned on. Each of LEDs can be turned on independently by setting the respective bit to 1.

Register REG2 allows to set the same current for all channels. REG3 and REG4 allow to set the current respectively in LED A and B. The LEDs can be programmed with independent current values.

REG5 contains the return lockout (RTLKO) bit. This stops the charge pump returning to 1-x mode. One pulse sets it to 1. Two pulses set RTLKO to 0. When RTLKO is set to 1, the charge pump cannot automatically return to 1-x mode when in one of the charge pump modes. The device can however move from 1-x to 1.5-x or 2-x if the input voltage is not sufficient to drive the programmed LED currents.

REG5 also triggers the internal charge pump. This forces the charge pump to start from 1-x mode and determine the correct mode it should operate to drive the LEDs most efficiently. If V_{IN} has risen or the device has been reprogrammed to other LED values, it is recommended to trigger this reset allowing the charge pump to run in the most efficient mode.

To power-down the device and turn-off all current sources, the EN/SET input should be kept low for a duration t_{OFF} of 1.5 ms or more. The driver typically powers-down with a delay of about 1 ms. All register data are cleared/reset.

Device allows multi flash mode operation using 1-wire interface. In this case, Registers 2, 3 or 4 should be programmed first to set output current. Register Reg1 should be used to start flash event with one or two channels depend on number of LED turned on. Flash starts $t_{DATADELAY}$ (2 ms) later after last data pulse. Use Reg1 address without data (one pulse) to turn off flash. Next flash event may start any time after $t_{RESETDELAY}$ (2 ms) by selecting register Reg1 with data. (See Figure 3 for an example – multi flash mode with maximum output current and all LEDs turned on during the flash.)

Protection Modes

The LDS8620 has follow protection modes:

1. LED short to V_{OUT} protection

If LED pin is shorted to V_{OUT}, LED burned out becomes as short circuit, or LED pin voltage is within (V_{OUT} - 1.5 V) range, LDS8620 recognizes this condition as “LED Short” and disables this channel with 750 µA control current. If LED pin voltage is less than (Vout – 1.5 V), LDS8620 restores LED current at this particular channel to programmed value.

2. V_{OUT} Over-Voltage Protection

The charge pump’ output voltage V_{OUT} automatically limits at about 6.2 V maximum. This is to prevent the output pin from exceeding its absolute maximum rating.

3. V_{OUT} Short Circuit Protection

If V_{OUT} is shorted to ground before LDS8620 is enabled, input current may increase up to 200 – 300 mA within 20 µs after enable and is limited to 35 – 40 mA after that.

4. Over-Temperature Protection

If the die temperature exceeds +150°C, the driver will enter shutdown mode. The LDS8620 requires restart after die temperature falls below 130°C.

5. Input Voltage Under-Voltage Lockout

If V_{IN} falls below 2.1 V (typical value), LDS8620 enters shutdown mode. Device requires restart when input voltage rises above 2.2 V.

6. Low V_{IN} or High LED V_F Voltage Detection

If, in 2-x mode, V_{IN} is too low to maintain regulated LED current for given LED V_F, or LED becomes an open circuit, or if any LED at active channels is disconnected, LDS8620 starts subsequently changing modes (2-x – 1-x – 1.5-x – 2-x -…) in an attempt to compensate insufficient voltage. As a result, average current at all other channels that are ON may be below regulated level.

LED Selection

LEDs with forward voltages (V_F) ranging from 1.6 V to 4.5 V may be used. Charge pumps operate in the highest efficiency mode when V_F voltage is close to Vin voltage multiplied by switching mode, i.e. Vin x 1, Vin x 1.5 and so on. If the voltage source is a Li-ion battery, we recommend selecting LED with V_F = 2.7 – 3.6 V to extend the battery life and achieve highest efficiency.

External Components

The LDS8620 requires two external 1 µF ceramic capacitors (X5R or X7R type) for decoupling input, output, and two 0.22 µF capacitors (X5R or X7R type) for the charge pump. In all charge pump modes, the input current ripple is very low, and an input bypass capacitor of 1 µF is sufficient.

In 1-x mode, the device operates in linear mode and does not introduce switching noise back onto the supply.

Recommended Layout

In charge pump mode, the driver switches internally at a high frequency. It is recommended to minimize trace length to all four capacitors. A ground plane should cover the area under the driver IC as well as the bypass capacitors. Short connection to ground on capacitors Cin and Cout can be implemented with the use of multiple via. A copper area matching the TQFN exposed pad (PAD) must be connected to the ground plane underneath. The use of multiple via improves the package heat dissipation.

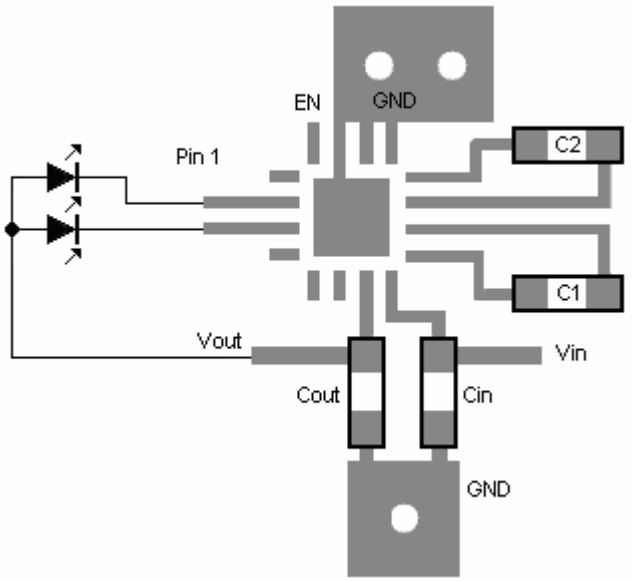
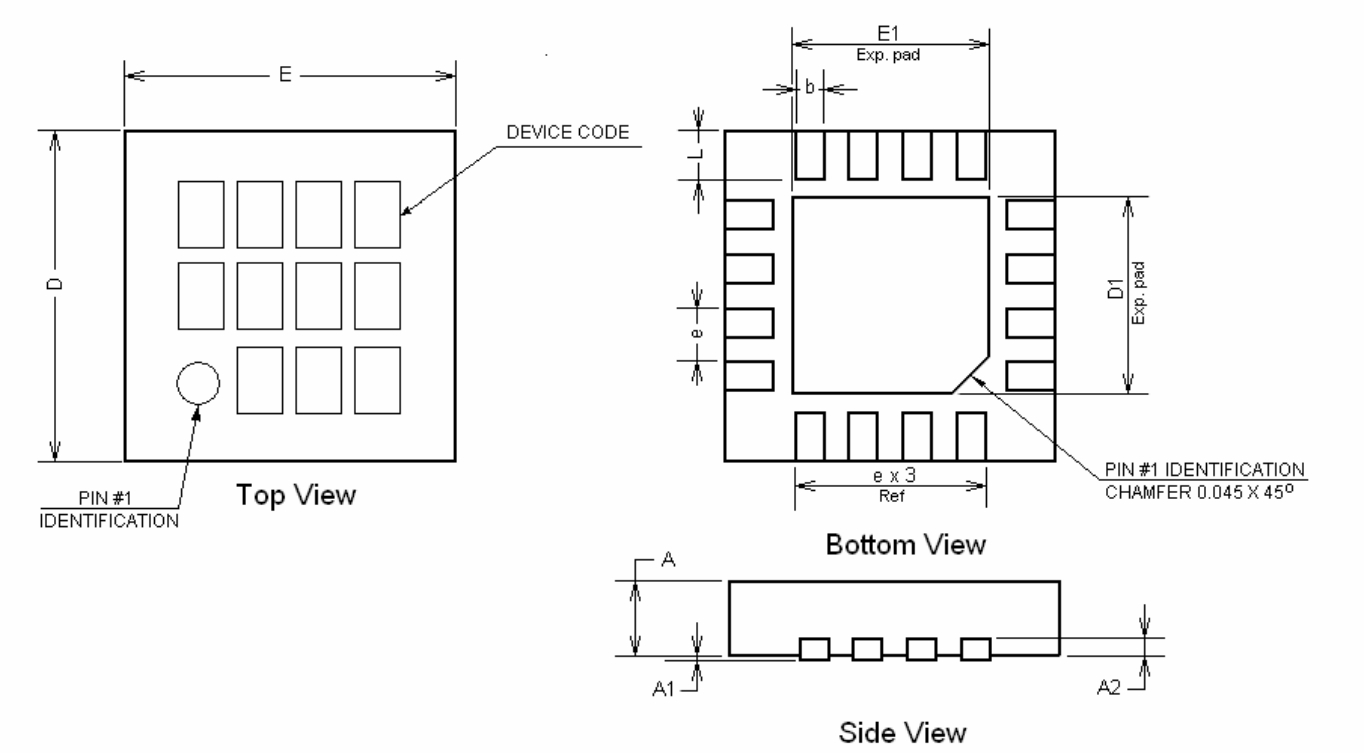


Figure 3. Recommended layout

PACKAGE DRAWING AND DIMENSIONS

16-PIN TQFN (HV3), 3mm x 3mm, 0.5mm PITCH



SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.178	0.203	0.228
b	0.18	0.23	0.28
D	2.90	3.00	3.10
D1	1.40	1.55	1.70
E	2.90	3.00	3.10
E1	1.40	1.55	1.70
e		0.50 typ	
L	0.35	0.40	0.45

Note:
1. All dimensions are in millimeters
2. Complies with JEDEC Standard MO-220

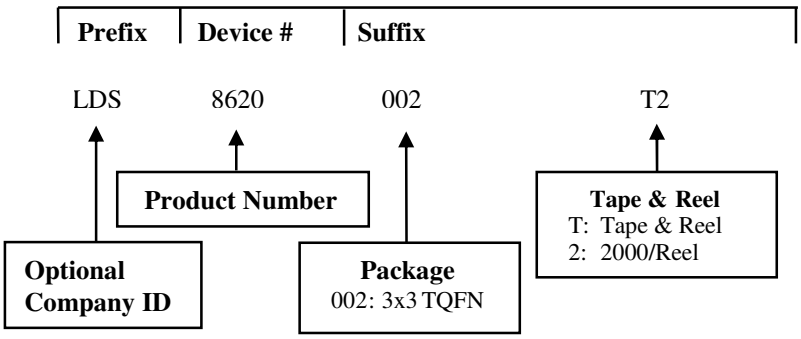
ORDERING INFORMATION

Part Number	Package	Package Marking
LDS8620 002-T2	TQFN-16 3 x 3mm(1)	8620

Notes:

1. Matte-Tin Plated Finish (RoHS-compliant)
2. Quantity per reel is 2000

EXAMPLE OF ORDERING INFORMATION



Notes:

1) All packages are RoHS-compliant (Lead-free, Halogen-free).
2) The standard lead finish is Matte-Tin.
3) The device used in the above example is a LDS8620 002–T2 (3x3 TQFN, Tape & Reel).
4) For additional package and temperature options, please contact your nearest IXYS Corp. Sales office.

Warranty and Use

IXYS CORP. MAKES NO WARRANTY, REPRESENTATION OR GUARANTEE, EXPRESS OR IMPLIED, REGARDING THE SUITABILITY OF ITS PRODUCTS FOR ANY PARTICULAR PURPOSE, NOR THAT THE USE OF ITS PRODUCTS WILL NOT INFRINGE ITS INTELLECTUAL PROPERTY RIGHTS OR THE RIGHTS OF THIRD PARTIES WITH RESPECT TO ANY PARTICULAR USE OR APPLICATION AND SPECIFICALLY DISCLAIMS ANY AND ALL LIABILITY ARISING OUT OF ANY SUCH USE OR APPLICATION, INCLUDING BUT NOT LIMITED TO, CONSEQUENTIAL OR INCIDENTAL DAMAGES.

IXYS Corp. products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the IXYS Corp. product could create a situation where personal injury or death may occur.

IXYS Corp. reserves the right to make changes to or discontinue any product or service described herein without notice. Products with data sheets labeled "Advance Information" or "Preliminary" and other products described herein may not be in production or offered for sale.

IXYS Corp. advises customers to obtain the current version of the relevant product information before placing orders. Circuit diagrams illustrate typical semiconductor applications and may not be complete.

IXYS Corp.
1590 Buckeye Dr.,
Milpitas, CA 95035-7418
Phone: 408.457.9000
Fax: 408.496.0222
http://www.ixys.com

Document No: 8620DS
Revision: N1.1
Issue date: 10/7/2009