FSP3302/FSP3303

FEATURES

- Two LED Configurations Available:
  FSP3302: Up to 4 LEDs
  FSP3303: Up to 6 LEDs
- High Efficiency Proprietary Charge Pump
- Automatic 1x/1.5x Mode-Switching
  Ensures Maximum Efficiency
- Wide 2.7V to 5.2V Input Voltage Range
- 0.3% White LED Brightness Matching
- Digitally Programmed 1dB Brightness Steps
  Up to 44mA per LED
- Automatic Programming Finish Detection
- 1.2MHz Operation for Low Ripple
- Simple Serial Interface
- Thermal Shutdown Protection
- Tiny QFN16L and µQFN16L Packages

APPLICATIONS

- Cell Phones
- Portable Devices

GENERAL DESCRIPTION

The FSP3302/FSP3303 are high performance, white LED bias generators for systems consisting of multiple white LEDs. The FSP3302/FSP3303 are identical except for the number of LEDs they drive; FSP3302 supports up to four LEDs, while FSP3303 can supply up to six LEDs.

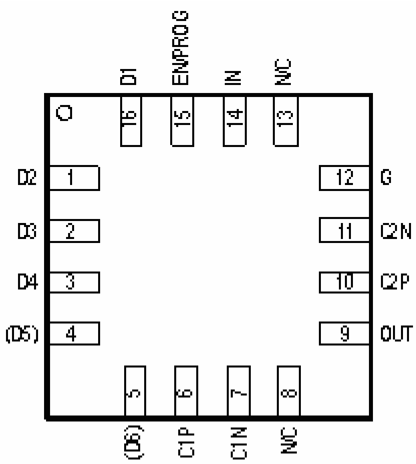
These devices integrate proprietary constant-frequency charge pump circuitry that includes automatic mode-switching to maximize efficiency with accurate, matched current sources that drive the white LEDs. Current matching is better than 0.3%, resulting in highly uniform brightness across different LED channels.

The FSP3302/FSP3303 feature adjustable LED bias currents, which are programmable through a simple serial interface. Charge pump operation at 1.2MHz allows the use of small capacitors and minimizes ripple. The devices also feature soft-start circuitry to limit inrush current during startup, and thermal shutdown protection.

The FSP3302/FSP3303 are available in space saving QFN16L and µQFN16L packages.

PIN CONFIGURATION

(Top View)



PIN DESCRIPTION

Pin Number	Pin Name	Pin Description
1	D2	LED Output 2
2	D3	LED Output 3
3	D4	LED Output 4
4	(D5)	LED Output 5 (FSP3303 only)
5	(D6)	LED Output 6 (FSP3303 only)
6	C1P	Flying Capacitor 1 Positive Terminal
7	C1N	Flying Capacitor 1 Negative Terminal
8	N/C	Not Connected
9	OUT	Charge Pump Output. Bypass to G with a 1μF ceramic capacitor.
10	C2P	Flying Capacitor 2 Positive Terminal
11	C2N	Flying Capacitor 2 Negative Terminal
12	G	Ground
13	N/C	Not Connected
14	IN	Input Supply. Bypass to G with a 1μF ceramic capacitor.
15	EN/PROG	IC Enable and Current Programming Pin
16	D1	LED Output 1

ABSOLUTE MAXIMUM RATINGS(NOTE)

Parameter		Value	Unit
IN Supply, OUT, EN/PROG to G		-0.3 to 6	V
D1, D2, D3, D4, D5, D6, C1P, C1N, C2P, C2N to G		-0.3 to VOUT + 0.3	V
C1N, C2N Voltage		-0.3 to VOUT + 1	V
D1, D2, D3, D4, (D5), (D6) Current		58	mA
Junction to Ambient Thermal Resistance (θ_{JA})	QFN16L	66	°C/W
	μQFN16L	66	
Operating Junction Temperature		-40 to 150	°C
Storage Temperature		-55 to 150	°C
Lead Temperature (Soldering, 10 sec)		300	°C

Note : Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(Circuit of the below Figure 1, V_{IN} = 3.5V, T_A = 25°C unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input Supply Range	V_{IN}		2.7		5.2	V
Supply Current	I_Q				3.5	mA
Shutdown Supply Current					1	µA
Full Scale Output Current	I_{DMAX}	V_{IN} = 3V to 5.5V, 4 LED channels active	38	44	49	mA
Output Current Matching		Between any two channels		0.3		%
Output Current Line Regulation				0.4		%/V
Charge Pump Switching Frequency	f_{QP}		1000	1200	1700	kHz
Soft-Start Time	t_{SS}			330		µs
Thermal Shutdown Temperature		Hysteresis = 20°C		160		°C
EN/PROG						
Logic Low Threshold	V_{IL}				0.5	V
Logic High Threshold	V_{IH}		1.4			V
Programming Low Time	t_{LOW}		0.3		75	µs
Programming Low Time to Reinitialize DAC after Finish	t_{LOW1}		5		75	µs
Programming Minimum High Time	$t_{HIGHMIN}$			50		ns
Programming High Time	t_{HIGH}				75	µs
Finish High Time	t_{FINISH}		500			µs
Off Timeout	t_{OFF}			300	500	µs
Input Current					1	µA

TYPICAL APPLICATION CIRCUIT

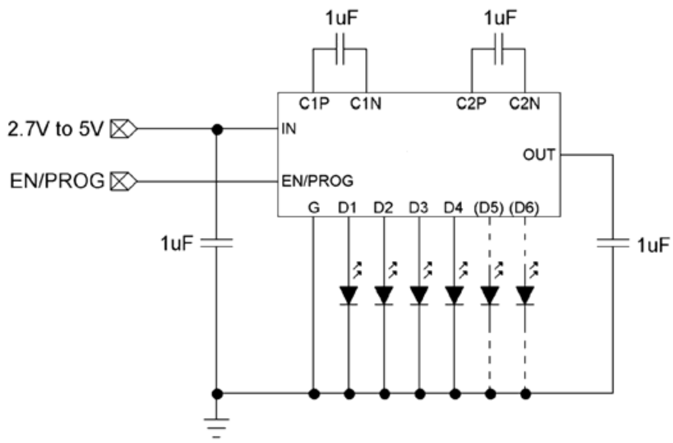
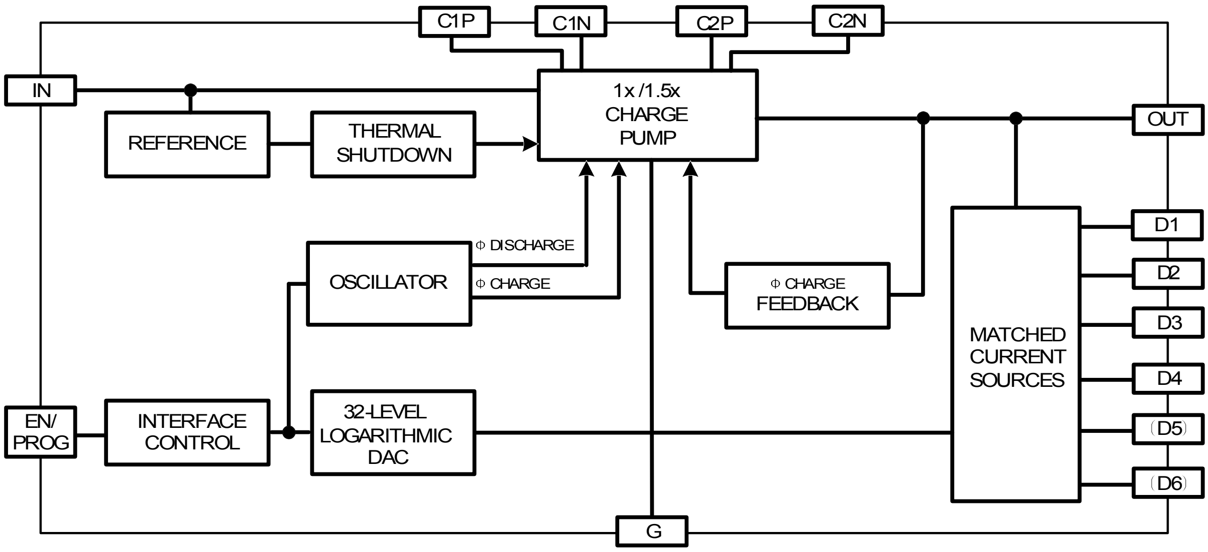


Figure 1

FUNCTIONAL BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

As shown in the Functional Block Diagram, the FSP3302/FSP3303 incorporate proprietary charge pump technology that includes automatic 1x/1.5x mode-switching to maximize efficiency. Accurate matched current sources are controlled by a 32-level logarithmic DAC in order to provide an accurate, efficient, and programmable bias supply for white LEDs.

CHARGE PUMP

The FSP3302/FSP3303 charge pump operates at 1.2MHz, and alternately charges and discharges the flying capacitors at C1P, C1N, C2P and C2N to generate sufficient output voltage at OUT to allow accurate biasing of white LEDs. These devices feature an automatic 1x/1.5x mode-switching charge pump architecture to ensure the highest possible efficiency for a charge pump solution. These devices utilize a proprietary regulation technique that minimizes the output impedance of the charge pump, allowing operation that is superior to competing products down to lower input voltages.

EN/PROG PIN

EN/PROG is a multi-function pin, providing both an enable/disable function as well as permitting the user a simple means to digitally program the LED current

ENABLE/DISABLE

If EN/PROG is driven low for more than 500µs (t_{OFF}), a DISABLE condition is detected and the IC is disabled. Conversely, if EN/PROG remains high for more than 500µs (t_{FINISH}), an ENABLE condition is detected, and the DAC is initialized to -31dB upon the next high to low transition of EN/PROG.

To properly reset the DAC upon enabling the IC, the input voltage should be applied first while EN/PROG is driven low. A subsequent low to high transition on EN/PROG pin turns the IC on.

PROGRAMMING LED CURRENT

The interface control block decodes the digital serial input signal at EN/PROG and produces a programming code for the 32-level logarithmic DAC. The logarithmic DAC sets the output currents to one of 32 different levels, in 1dB steps, with the highest level of 0dB corresponding to the full-scale current of 44mA. Logarithmic current scaling results in linear increments in LED brightness. When enabled (on an EN/PROG rising edge), the DAC initializes to its -31dB level. Thereafter, each high to low transition of the EN/PROG pin that occurs within 75µs increments the

DAC, and therefore the LED current, by 1dB. Once the maximum current level of 0dB is reached, an additional high to low transition on EN/PROG resets the DAC level to its minimum value of -31dB. Figure 2 demonstrates the EN/PROG serial protocol.

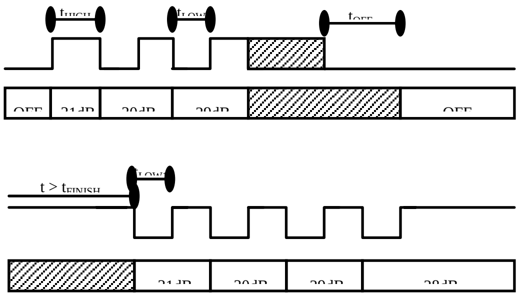


Figure2. EN/PROG Serial Protocol

To ensure proper DAC initialization, the first low pulse after programming is completed should be at least 5μs.

SOFT START

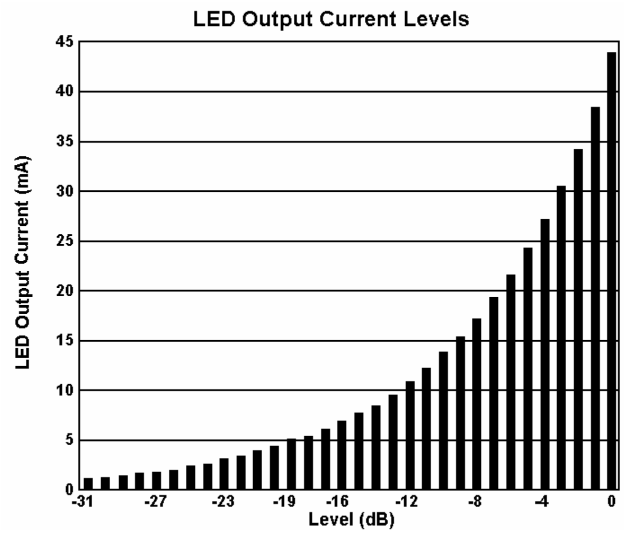
When enabled, the FSP3302/FSP3303 operate in a low power state for 330μs (t_{SS}) to limit inrush current. After this time has expired, the devices operate in full-power mode.

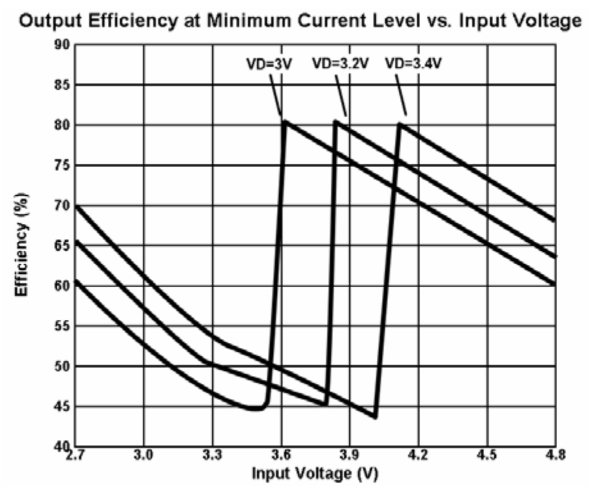
THERMAL SHUTDOWN

In order to protect themselves under thermal overload and short circuit conditions, the FSP3302/FSP3303 incorporate thermal shutdown circuitry that monitors the die temperature and disables the IC if it exceeds 160°C.

■ TYPICAL PERFORMANCE CHARACTERISTICS

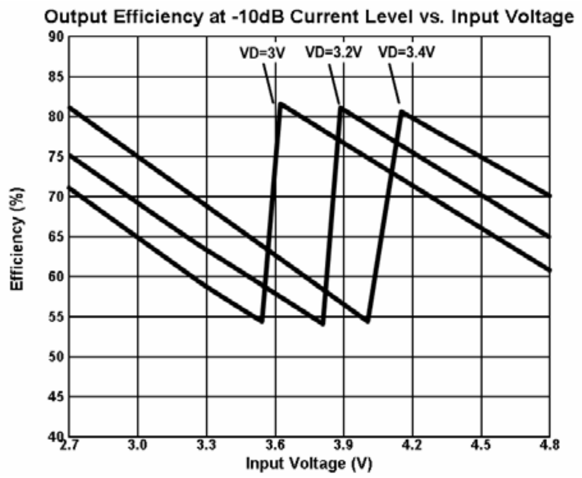
(Circuit of Figure 1, V_{IN} = 3.5V, T_A = 25°C unless otherwise specified.)

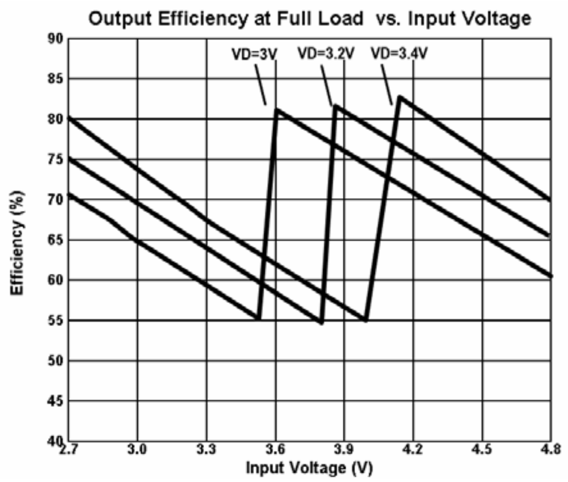


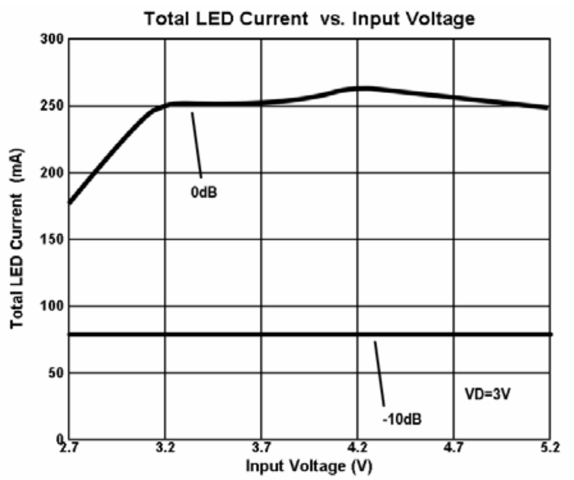


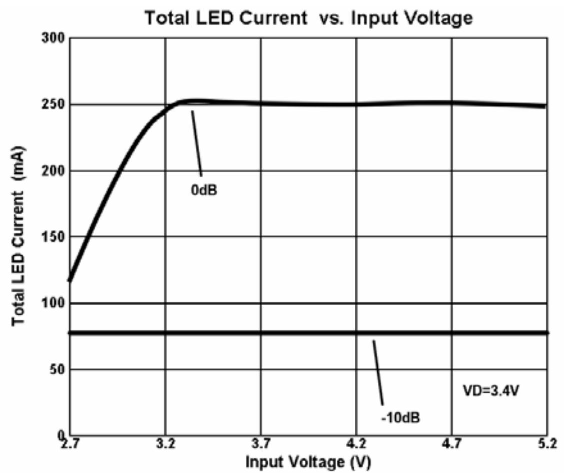
■ TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

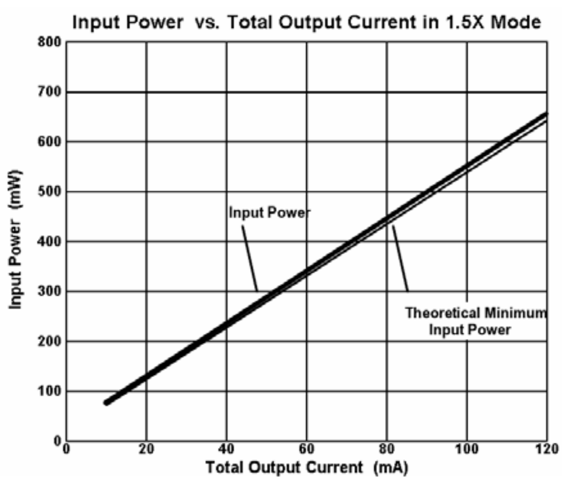
(Circuit of Figure 1, V_{IN} = 3.5V, T_A = 25°C unless otherwise specified.)

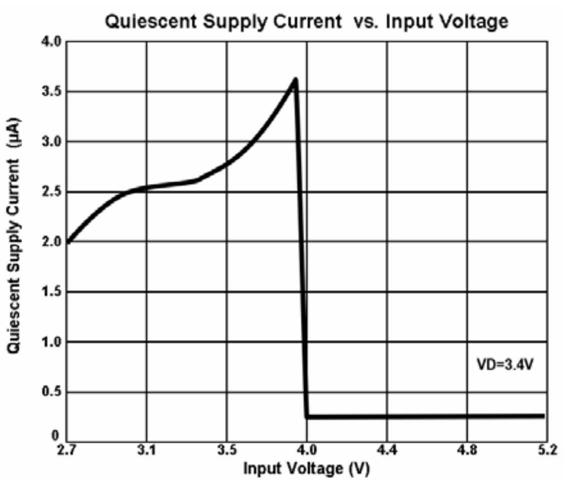






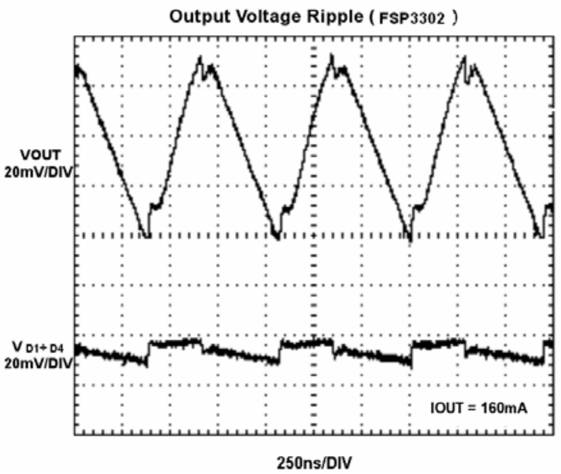


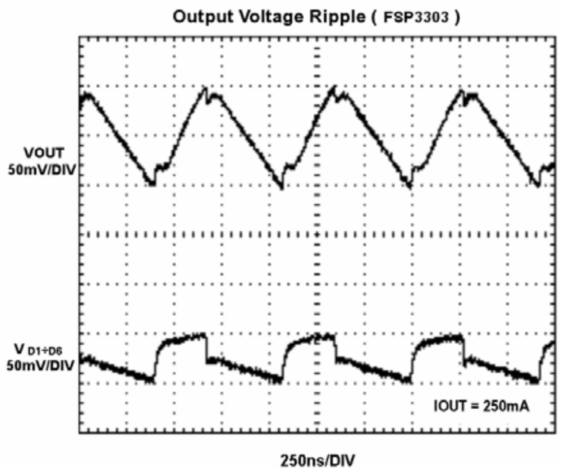




■ TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

(Circuit of Figure 1, V_{IN} = 3.5V, T_A = 25°C unless otherwise specified.)





■ APPLICATION INFORMATION

CAPACITOR SELECTION

For best performance, use only ceramic capacitors, as they offer small size, low ESR, low cost, and high reliability. Since the dropout resistance is dependent on the ESR of the capacitors, lower ESR also allows the circuit to supply the required output currents at lower input voltage. X7R and X5R ceramic types are most stable (±15%) over bias voltage and temperature ranges and thus are highly recommended. Lower cost Y5V and Z5U ceramic types vary widely with voltage and temperature, and they should only be used after careful verification of the effects the capacitance degradation has on the application.

Choose values for the flying capacitors of at least 1µF. For best results choose input and output capacitors of at least 1µF.

WHITE LED SELECTION

The FSP3302/FSP3303 are designed to bias multiple parallel white LEDs. The LED currents are internally matched and change very little with each LED's forward voltage. For best operation, ensure that the maximum LED forward voltage is 4.2V.

The FSP3302/FSP3303 utilizes a proprietary design that results in significantly better dropout performance than competing products. Whereas other products maintain constant current for input voltages down to 3.0V, the FSP3302/FSP3303 are capable of providing constant output current for input voltages extending down to as low as 2.7V.

EFFICIENCY

The FSP3302/FSP3303 automatically adjust their operating mode to ensure the highest possible efficiency for a given set of operating conditions. The theoretical maximum efficiency of a charge pump is a function of its operating mode, and is given by $\eta_{MAX} = V_{LED} / KV_{IN}$ where K is equal to 1 for a 1x operating mode and 1.5 for a 1.5x operating mode. Compared to this theoretical maximum efficiency, the FSP3302/FSP3303 achieve efficiency that is within just 2% of the theoretical maximum for full scale output currents. This ensures the lowest possible battery current and the maximum possible battery life in portable applications.

■ ORDERING INFORMATION

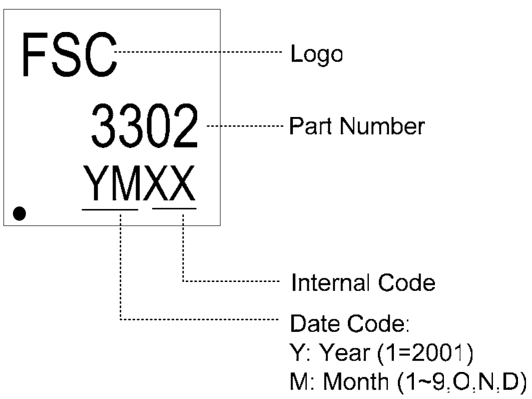
FSP3302/FSP3303XXX

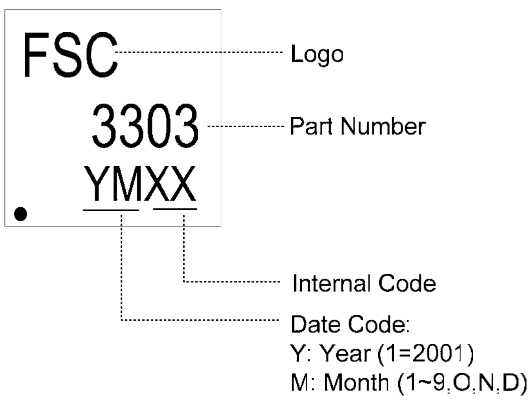
Package:
Q: QFN16L
μQ: μQFN 16L

Packing:
A: Tape & Reel

Temperature Grade:
D: -40~85℃

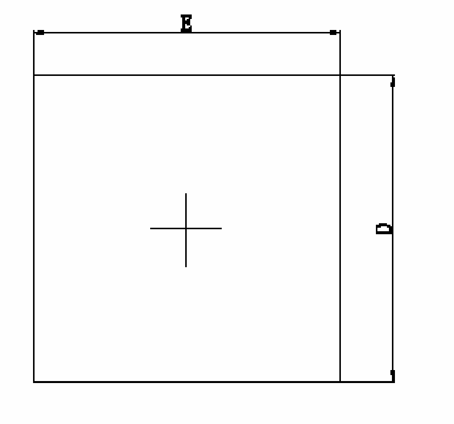
■ MARKING INFORMATION

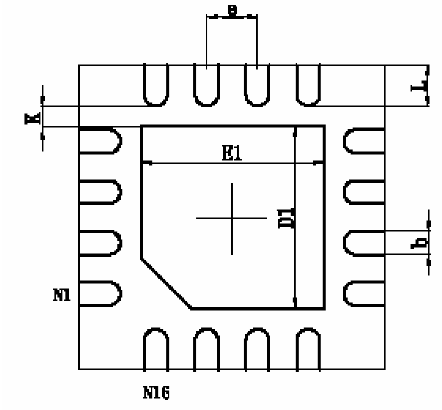


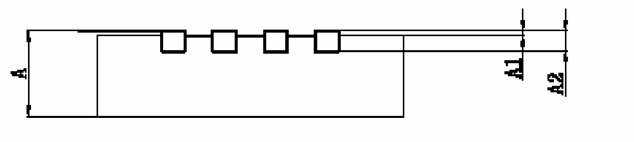


■ PACKAGE INFORMATION

(1) QFN16L

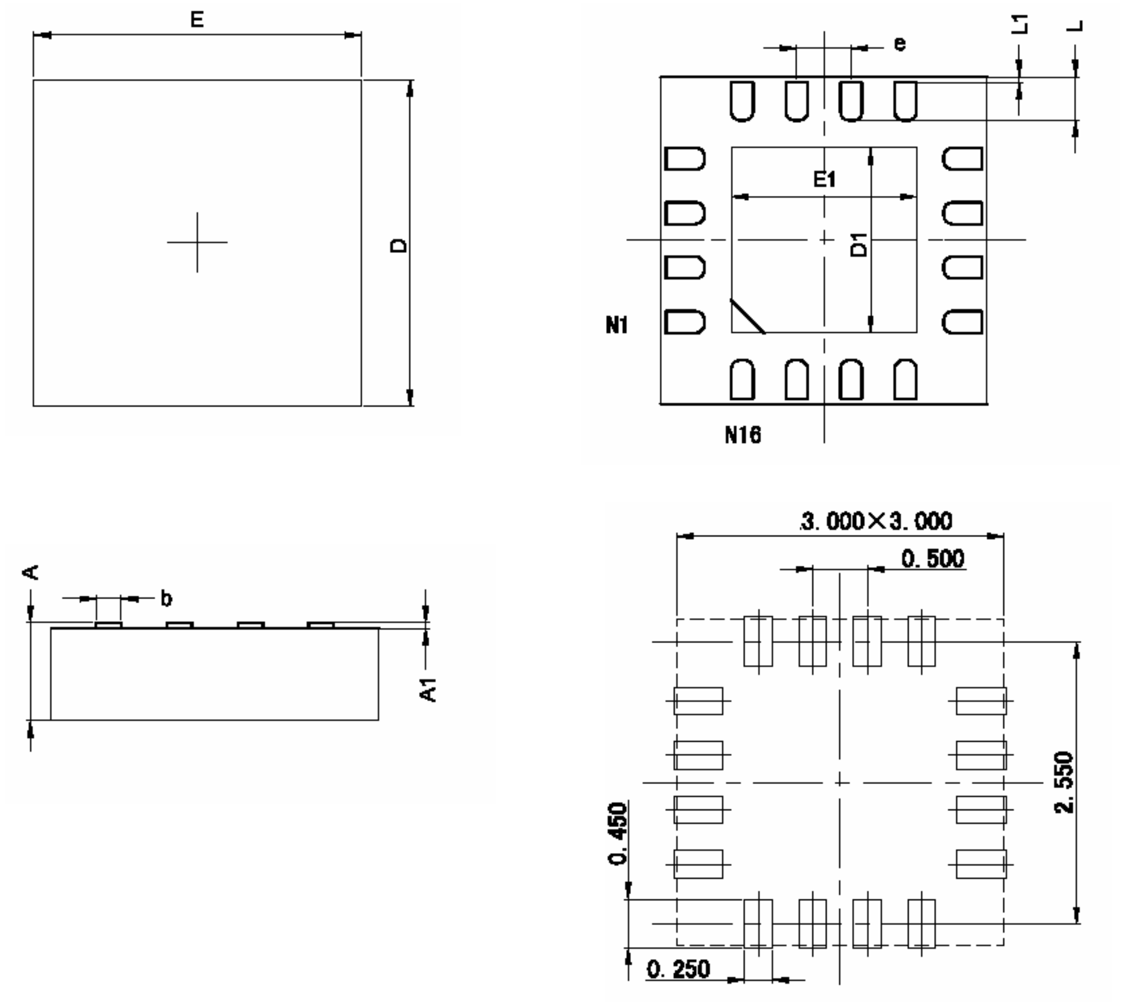






Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.200 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
D1	1.500	1.700	0.059	0.067
E1	1.500	1.700	0.059	0.067
b	0.180	0.280	0.007	0.011
e	0.500 BSC		0.020 BSC	
L	0.350	0.450	0.014	0.018
K	0.200	0.400	0.008	0.016

(2) µQFN16L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A		0.900		0.035
A1	0.010	0.090	0.0004	0.0035
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
D1	1.700		0.067	
E1	1.700		0.067	
b	0.150	0.250	0.006	0.010
e	0.500 BSC		0.020 BSC	
L	0.350	0.450	0.014	0.018
L1	0.000	0.050	0.000	0.002