19-2107; Rev 1; 8/02

MAXIM

Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

General Description

The MAX1595 charge-pump regulator generates either 3.3V or 5V from a 1.8V to 5.5V input. The unique control architecture allows the regulator to step up or step down the input voltage to maintain output regulation. The 1MHz switching frequency, combined with a unique control scheme, allows the use of a ceramic capacitor as small as 1µF for 125mA of output current. The complete regulator requires three external capacitors—no inductor is needed. The MAX1595 is specifically designed to serve as a high-power, high-efficiency auxiliary supply in applications that demand a compact design. The MAX1595 is offered in space-saving 8-pin µMAX and high-power 12-pin thin QFN packages.

Applications

White LED Power

Flash Memory Supplies

Battery-Powered Applications

Miniature Equipment

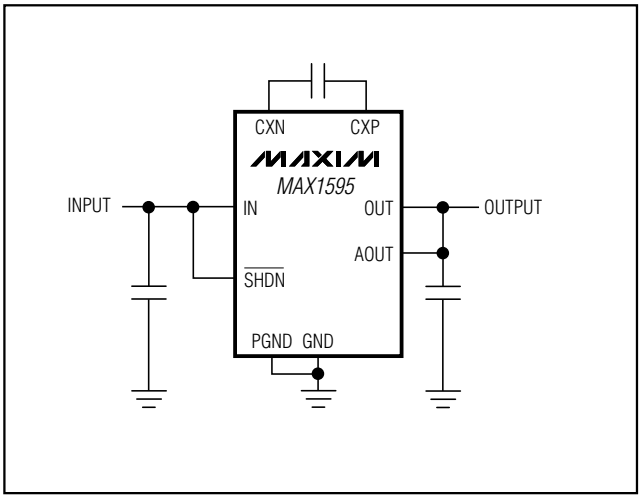
PCMCIA Cards

3.3V to 5V Local Conversion Applications

Backup-Battery Boost Converters

3V to 5V GSM SIMM Cards

Typical Operating Circuit



Features

- **Ultra-Small: Requires Only Three Ceramic Capacitors**
- **No Inductors Required**
- **Up to 125mA Output Current**
- **Regulated ±3% Output Voltage**
- **1MHz Switching Frequency**
- **1.8V to 5.5V Input Voltage**
- **220µA Quiescent Current**
- **0.1µA Shutdown Current**
- **Load Disconnect in Shutdown**

Ordering Information

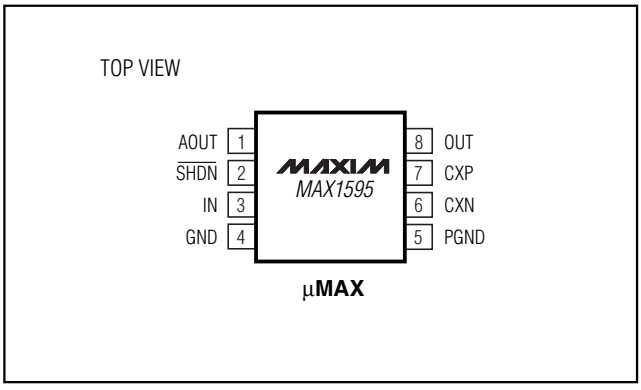
PART	TEMP RANGE	PIN-PACKAGE
MAX1595EUA33	-40°C to +85°C	8 µMAX
MAX1595ETC33	-40°C to +85°C	12 Thin QFN
MAX1595EUA50	-40°C to +85°C	8 µMAX
MAX1595ETC50	-40°C to +85°C	12 Thin QFN

Selector Guide

PART	V_{OUT} *	TOP MARK
MAX1595EUA33	3.3V	—
MAX1595ETC33	3.3V	AAAP
MAX1595EUA50	5.0V	—
MAX1595ETC50	5.0V	AAAM

**Contact factory for other fixed-output voltages from 2.7V to 5.0V.*

Pin Configurations



Pin Configurations continued at end of data sheet.

Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

ABSOLUTE MAXIMUM RATINGS

IN, OUT, AOUT to GND .....-0.3V to +6V
$\overline{SHDN}$ to PGND .....-0.3V to +6V
PGND to GND .....-0.3V to +0.3V
CXN to PGND .....-0.3V to (Lower of IN + 0.8V or 6.3V)
CXP to GND .....-0.8V to (Higher of OUT + 0.8V or IN + 0.8V but not greater than 6V)
Continuous Output Current 150mA

Continuous Power Dissipation (T_A = +70°C)
8-Pin µMAX (derate 4.5mW/°C above +70°C) 362mW
12-Pin Thin QFN (derate 18.5mW/°C above +70°C) 1481mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 2V for MAX1595_ _ _33, V_{IN} = 3V for MAX1595_ _ _50, C_{IN} = 1µF, C_X = 0.22µF, C_{OUT} = 1µF, T_A = -40° to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

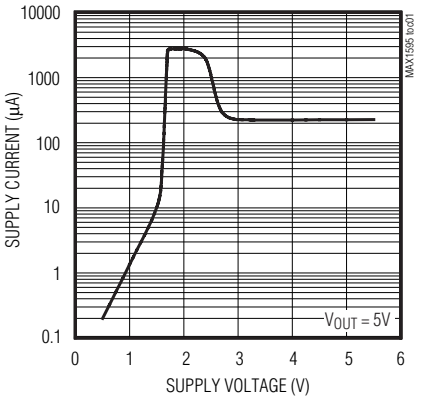
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			1.8		5.5	V
Input Undervoltage Lockout Threshold				1.40	1.60	1.72	V
Input Undervoltage Lockout Hysteresis					40		mV
Output Voltage	V_{OUT}	0 < I_{LOAD} < 125mA, V_{IN} = +3.0V	T_A = 0 to +85°C	4.85	5.05	5.15	V
			T_A = -40°C to +85°C	4.80		5.20	
		0 < I_{LOAD} < 75mA, V_{IN} = +2.0V	T_A = 0 to +85°C	3.20	3.33	3.40	
			T_A = -40°C to +85°C	3.16		3.44	
		0 < I_{LOAD} < 30mA, V_{IN} = +1.8V	T_A = 0 to +85°C	3.20	3.33	3.40	
			T_A = -40°C to +85°C	3.16		3.44	
No-Load Input Current	I_Q	V_{IN} = +2.0V, MAX1595_ _ _33			220	320	µA
		V_{IN} = +3.0V, MAX1595_ _ _50			240	350	
Switching Frequency	f_{OSC}	I_{LOAD} > 20mA, V_{OUT} > V_{IN}		0.85	1.0	1.15	MHz
Shutdown Supply Current	$I_{\overline{SHDN}}$	$\overline{SHDN}$ = 0, V_{IN} = +5.5V, V_{OUT} = 0				5	µA
$\overline{SHDN}$ Input Voltage Low	V_{INL}	V_{IN} = 2.0V to 5.5V				0.6	V
$\overline{SHDN}$ Input Voltage High	V_{INH}	V_{IN} = 2.0V to 5.5V		1.6			V
$\overline{SHDN}$ Input Leakage Current						0.1	µA

Note 1: Specifications to -40°C are guaranteed by design, not production tested.

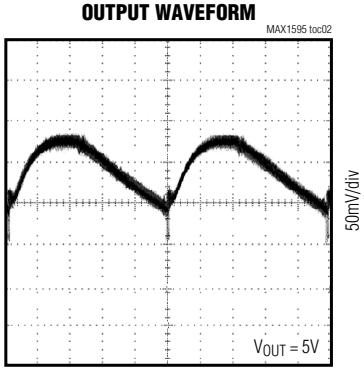
Typical Operating Characteristics

(Circuit of Figure 4, V_{IN} = 2V for MAX1595_ _ _33, V_{IN} = 3V for MAX1595_ _ _50, T_A = +25°C, unless otherwise noted.)

NO LOAD SUPPLY CURRENT vs. SUPPLY VOLTAGE

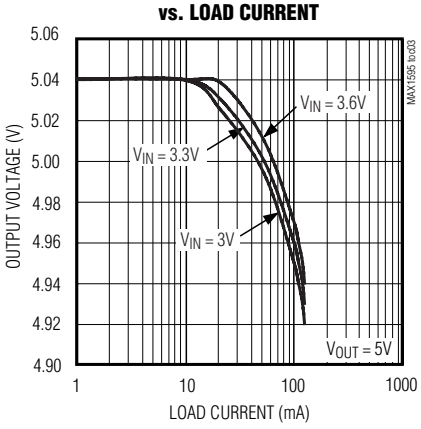


OUTPUT WAVEFORM

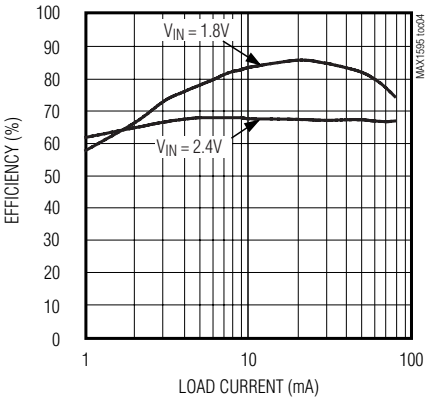


OUTPUT WAVEFORM. AC-COUPLED.
V_{IN} = 3.6V, I_{LOAD} = 100mA, C_{OUT} = 1µF

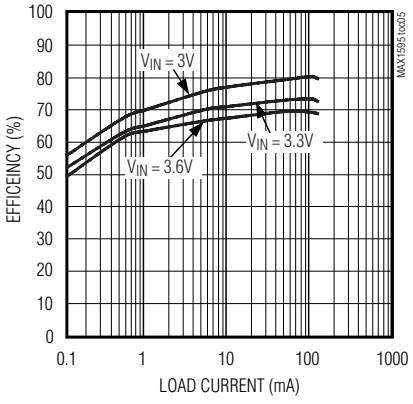
OUTPUT VOLTAGE vs. LOAD CURRENT



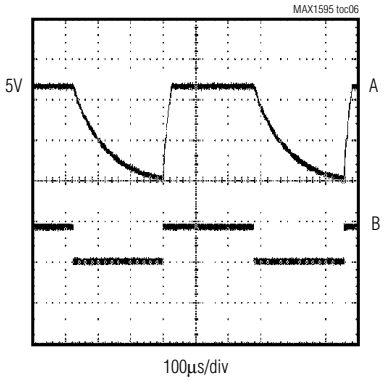
3V EFFICIENCY vs. LOAD CURRENT



5V EFFICIENCY vs. LOAD CURRENT

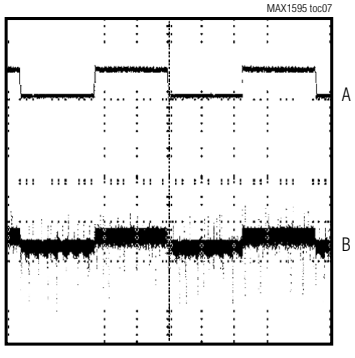


SHUTDOWN TIMING



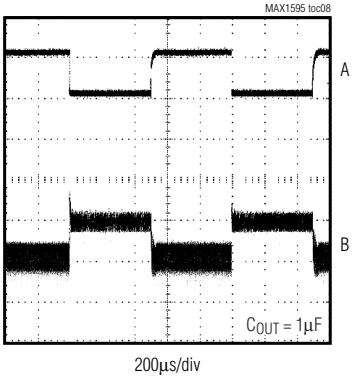
A: OUTPUT VOLTAGE: R_L = 100Ω, 2V/div
B: $\overline{SHDN}$ VOLTAGE: 2V/div

LINE-TRANSIENT RESPONSE



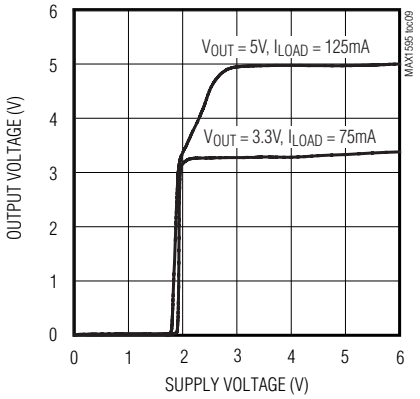
A: INPUT VOLTAGE: V_{IN} = 3.1V TO 3.6V, 500mV/div
B: OUTPUT VOLTAGE: I_{LOAD} = 50mA, 100mV/div

LOAD-TRANSIENT RESPONSE



A: LOAD CURRENT: I_{LOAD} = 5mA to 95mA, 100mA/div
B: OUTPUT VOLTAGE: AC-COUPLED 100mV/div

OUTPUT VOLTAGE vs. SUPPLY VOLTAGE



Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

Pin Description

PIN		NAME	FUNCTION
MAX1595 µMAX	MAX1595 THIN QFN		
1	12	AOUT	Analog Power and Sense Input for Error Amplifier/Comparator. Connect to OUT at output filter capacitor.
2	1	$\overline{SHDN}$	Shutdown Input. When $\overline{SHDN}$ = low, the device turns off; when $\overline{SHDN}$ = high, the device activates. In shutdown, OUT is disconnected from IN.
3	2, 3	IN	Input Supply. Can range from 1.8V to 5.5V. Bypass to GND with a 1µF capacitor.
4	4	GND	Ground
5	5, 6	PGND	Power Ground
6	7, 8	CXN	Negative Terminal of the Charge-Pump Transfer Capacitor
7	9	CXP	Positive Terminal of the Charge-Pump Transfer Capacitor
8	10, 11	OUT	Output. Bypass to GND with output capacitor filter.

Detailed Description

The MAX1595 charge pump provides either a 3.3V or 5V regulated output. It delivers a maximum 125mA load current. In addition, to boost regulating from a lower supply, it is also capable of buck regulating from supplies that exceed the regulated output by a diode drop or more. Designed specifically for compact applications, a complete regulator circuit requires only three small external capacitors. An innovative control scheme provides constant frequency operation from medium to heavy loads, while smoothly transitioning to low-power mode at light loads to maintain optimum efficiency. In buck mode, switch S1 (in Figure 1) is switched continuously to IN, while switch S2 alternates between IN and OUT. An amount of charge proportional to the difference between the output voltage and the supply voltage is stored on C_X, which gets transferred to the output when the regulation point is reached. Maximum output ripple is proportional to the difference between the supply voltage and the output voltage, as well as to the ratio of the transfer capacitor (C_X) to the output capacitor (C_{OUT}).

The MAX1595 consists of an error amplifier, a 1.23V bandgap reference, internal resistive feedback network, oscillator, high-current MOSFET switches, and shutdown and control logic. Figure 1 shows an idealized unregulated charge-pump voltage doubler. The oscillator runs at a 50% duty cycle. During one half of the period, the transfer capacitor (C_X) charges to the input voltage. During the other half, the doubler transfers the sum of C_X and input voltage to the output filter capacitor (C_{OUT}). Rather than doubling the input voltage, the MAX1595 provides a regulated output voltage of either 3.3V or 5.0V.

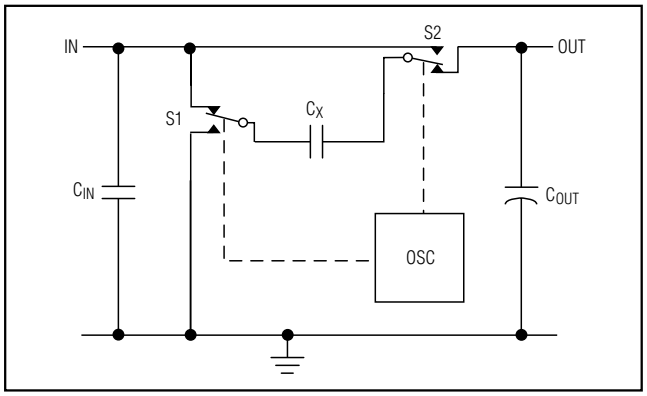


Figure 1. Unregulated Voltage Doubler

Shutdown

Driving $\overline{SHDN}$ low places the device in shutdown mode. The device draws 0.1µA of supply current in this mode. When driven high, the MAX1595 enters a soft-start mode. Soft-start mode terminates when the output voltage regulates, or after 2ms, whichever comes first. In shutdown, the output disconnects from the input.

Undervoltage Lockout

The MAX1595 has an undervoltage-lockout that deactivates the devices when the input voltage falls below 1.6V. Below UVLO, hysteresis holds the device in shutdown until the input voltage rises 40mV above the lockout threshold.

Applications Information

Using white LEDs to backlight LCDs is an increasingly popular approach for portable information devices (Figure 2). Because the forward voltage of white LEDs

exceeds the available battery voltage, the use of a charge pump such as the MAX1595 provides high efficiency, small size, and constant light output with changing battery voltages. If the output is used only to light LEDs, the output capacitor can be greatly reduced. The frequency modulation of the LED intensity is not discernible to the human eye, and the smaller capacitor saves both size and cost.

Adding two Schottky diodes and two capacitors implements a tripler and allows the MAX1595_ _ _50 to regulate a current of 75mA with a supply voltage as low as 2.3V (Figure 3).

Capacitor Selection

The MAX1595 requires only three external capacitors (Figure 4). Their values are closely linked to the output current capacity, oscillator frequency, output noise content, and mode of operation.

Generally, the transfer capacitor (C_X) will be the smallest, and the input capacitor (C_{IN}) is twice as large as C_X. Higher switching frequencies allow the use of the smaller C_X and C_{IN}. The output capacitor (C_{OUT}) can be anywhere from 5-times to 50-times larger than C_X. Table 1 shows recommended capacitor values.

In addition, the following equation approximates output ripple:

$$V_{RIPPLE} \cong I_{OUT} / (2 \times f_{OSC} \times C_{OUT})$$

Table 2 lists the manufacturers of recommended capacitors. Ceramic capacitors will provide the lowest ripple due to their typically lower ESR.

Power Dissipation

The power dissipated in the MAX1595 depends on output current and is accurately described by:

$$P_{DISS} = I_{OUT} (2V_{IN} - V_{OUT})$$

P_{DISS} must be less than that allowed by the package rating.

Layout Considerations

All capacitors should be soldered in close proximity to the IC. Connect ground and power ground through a short, low-impedance trace. The input supply trace should be as short as possible. Otherwise, an additional input supply filter capacitor (tantalum or electrolytic) may be required.

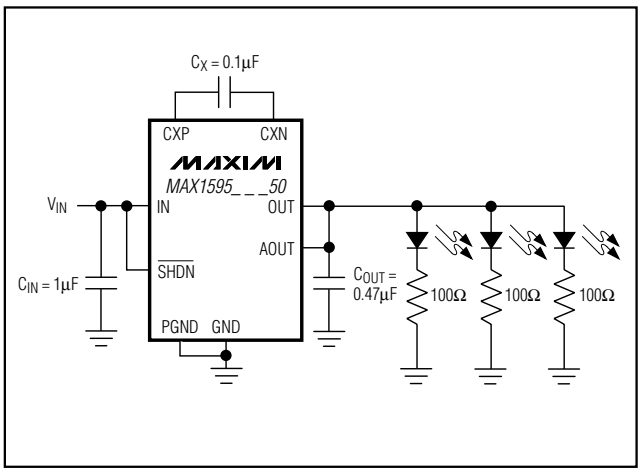


Figure 2. White LED Bias Supply

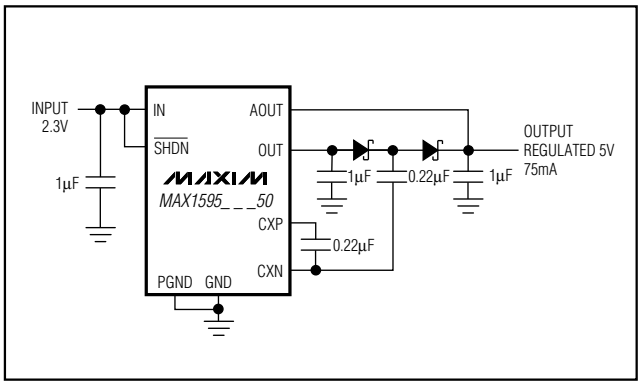


Figure 3. Regulated Voltage Tripler

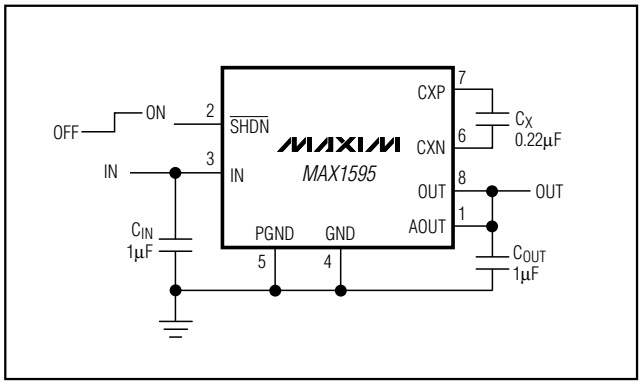


Figure 4. Standard Operating Circuit

Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

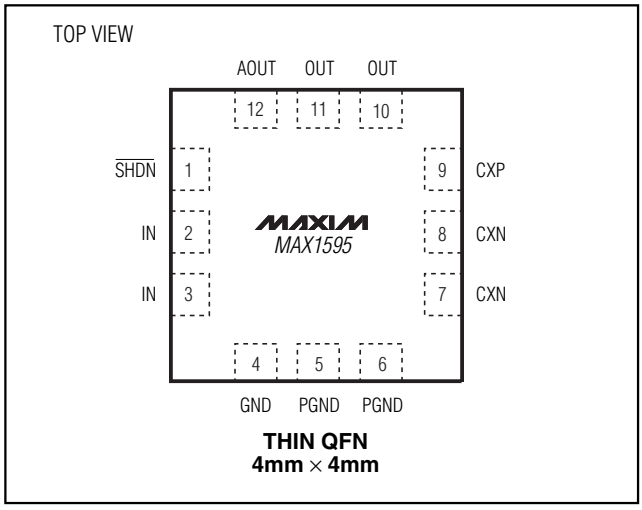
Table 1. Recommended Capacitor Values

OUTPUT RIPPLE (mV)	C_{IN} (µF)	C_X (µF)	C_{OUT} (µF)
70	1	0.22	1
35	2.2	0.47	2.2

Table 2. Recommended Capacitor Manufacturers

VALUE (µF)	VOLTAGE (V)	TYPE	SIZE	MANUFACTURER	PART
1	10	X7R	0805	Taiyo Yuden	LMK212BJ105MG
0.22	10	X7R	0603	Taiyo Yuden	LMK107BJ224MA
0.47	10	X7R	0603	Taiyo Yuden	LMK107BJ474MA
0.1	10	X7R	0603	Taiyo Yuden	LMK107BJ104MA

Pin Configurations (continued)



THIN QFN
4mm × 4mm

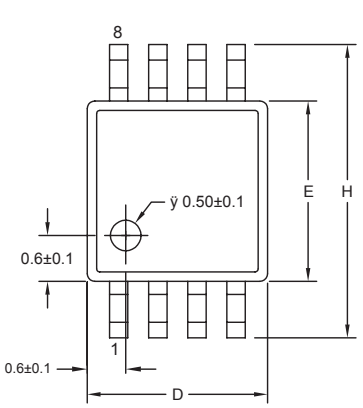
Chip Information

TRANSISTOR COUNT: 1370

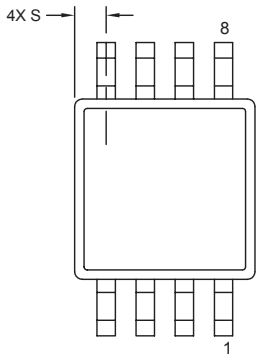
Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

8LUMAXD.EPS

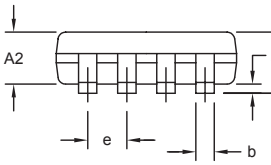


TOP VIEW

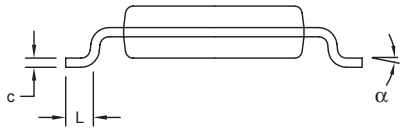


BOTTOM VIEW

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0∞	6∞	0∞	6∞
S	0.0207 BSC		0.5250 BSC	



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

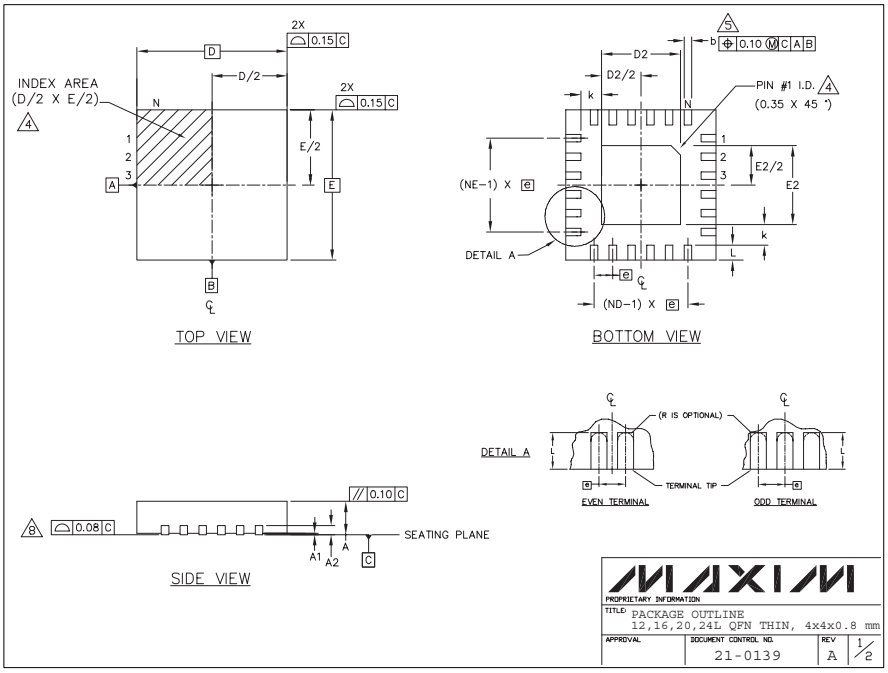
TITLE: PACKAGE OUTLINE, 8L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0036	J	1/1

Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



COMMON DIMENSIONS												
PKG	12L 4x4			16L 4x4			20L 4x4			24L 4x4		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05
A2	0.20 REF			0.20 REF			0.20 REF			0.20 REF		
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.18	0.23	0.30
D	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
E	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
e	0.80 BSC.			0.65 BSC.			0.50 BSC.			0.50 BSC.		
k	0.25	–	–	0.25	–	–	0.25	–	–	0.25	–	–
L	0.45	0.55	0.65	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16			20			24		
ND	3			4			5			6		
NE	3			4			5			6		
Jedec Var.	WGGB			WGGC			WGGD-1			WGGD-2		

EXPOSED PAD VARIATIONS						
PKG. CODES	D2			E2		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
T1244-2	1.95	2.10	2.25	1.95	2.10	2.25
T1644-2	1.95	2.10	2.25	1.95	2.10	2.25
T2044-1	1.95	2.10	2.25	1.95	2.10	2.25
T2444-1	2.45	2.60	2.63	2.45	2.60	2.63

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220.

PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE
12,16,20,24L QFN THIN, 4x4x0.8 mm
APPROVAL
DOCUMENT CONTROL NO. 21-0139
REV A
2/2

MAX1595

Part Number Table

Notes:

1. See the MAX1595 QuickView Data Sheet for further information on this product family or download the MAX1595 full data sheet (PDF, 356kB).
2. Other options and links for purchasing parts are listed at: http://www.maxim-ic.com/sales.
3. Didn't Find What You Need? Ask our applications engineers. Expert assistance in finding parts, usually within one business day.
4. Part number suffixes: T or T&R = tape and reel; + = RoHS/lead-free; # = RoHS/lead-exempt. More: See full data sheet or Part Naming Conventions.
5. * Some packages have variations, listed on the drawing. "PkgCode/Variation" tells which variation the product uses.

Part Number	Free Sample	Buy Direct	Package: TYPE PINS SIZE DRAWING CODE/VAR *	Temp	RoHS/Lead-Free? Materials Analysis
MAX1595EGC50-T				-40C to +85C	RoHS/Lead-Free: No
MAX1595EGC33			QFN;12 pin;4x4x0.9mm Dwg: 21-0106E (PDF) Use pkgcode/variation: G1244-2*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EGC33-T				-40C to +85C	RoHS/Lead-Free: No
MAX1595EGC50				-40C to +85C	RoHS/Lead-Free: No
MAX1595ETC50+T			THIN QFN;12 pin;4X4X0.8mm Dwg: 21-0139E (PDF) Use pkgcode/variation: T1244+4*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX1595ETC50+			THIN QFN;12 pin;4X4X0.8mm Dwg: 21-0139E (PDF) Use pkgcode/variation: T1244+4*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX1595ETC50			THIN QFN;12 pin;4X4X0.8mm Dwg: 21-0139E (PDF) Use pkgcode/variation: T1244-4*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis

MAX1595ETC50-T			THIN QFN;12 pin;4X4X0.8mm Dwg: 21-0139E (PDF) Use pkgcode/variation: T1244-4*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EUA33+T			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8+1*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX1595EUA33+			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8+1*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX1595EUA50-T			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8-1*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EUA50+T			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8+1*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis
MAX1595EUA50			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8-1*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EUA33-T			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8-1*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EUA33			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8-1*	-40C to +85C	RoHS/Lead-Free: No Materials Analysis
MAX1595EUA50+			uMAX;8 pin;3 x 3mm Dwg: 21-0036J (PDF) Use pkgcode/variation: U8+1*	-40C to +85C	RoHS/Lead-Free: Yes Materials Analysis

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