G5930/G5930A

Switched Capacitor Voltage Inverter with Shutdown

Features

- **Inverts Input Supply Voltage**
- **60mA Output Current with a Voltage Drop of 580mV**
- **0.52mA Quiescent Current at 3.3V Supply Voltage**
- **99% Voltage Conversion Efficiency**
- **1.8V to 5V operating range**
- **Require Only Two Capacitors**
- **Over-Temperature Protection**
- **Logic Controlled Shutdown**
- **6-Pin SOT-23 Package and TDFN2X2 6-pin Package**
- **5-Pin SOT-23 Package without shutdown function (G5930A)**

Applications

- **Cell Phone**
- **Small LCD Panels**
- **Portable Equipment**
- **Handy-Terminals, PDAs**
- **Battery-Operated Equipment**

General Description

The G5930 is an unregulated charge-pump voltage inverter which may be used to generate a negative supply from positive input. Input voltages ranging from +1.8V to +5V can be inverted into a -1.8V to -5V output supply. The devices are ideal for both battery-powered and board level voltage conversion applications with a typical operating current of 0.52mA at 3.3V supply.

The G5930 can deliver 60mA output current with a voltage drop of 580mV. The parts are over –temperature protected.

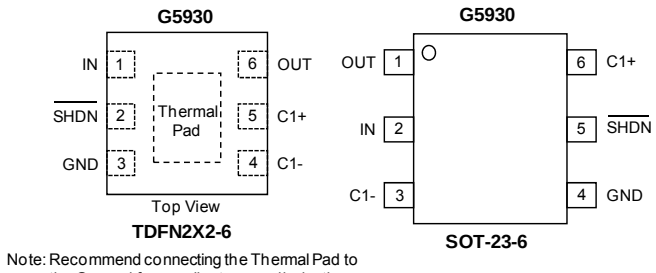
Applications include cell phones, PDAs, and other portable equipment. The device is available in a space-saving SOT-23-6, TDFN2X2-6 and SOT-23-5 Package.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G5930TBU	5930x	-40°C to 85°C	SOT-23-6
G5930RB1U	5930	-40°C to 85°C	TDFN2X2-6
G5930AT11G	590Ax	-40°C to 85°C	SOT-23-5

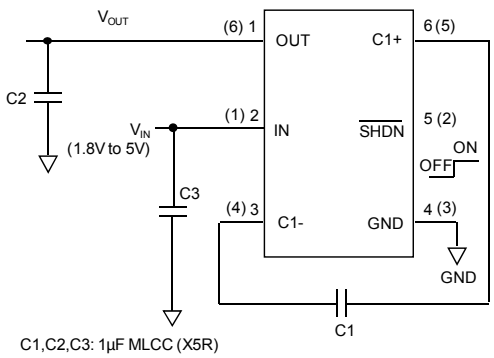
Note: TB : SOT-23-6 RB: TDFN2X2-6 T1:SOT-23-5
1: Bonding Code (only TDFN2X2-6 & SOT-23-5)
U&G: Tape & Reel
Green: Lead free / Halogen free

Pin Configuration



Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

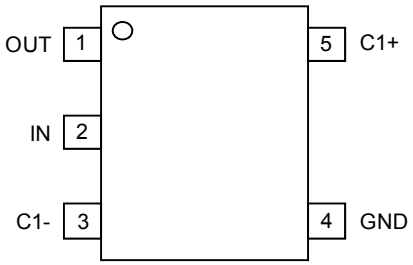
Typical Application Circuit



C1,C2,C3: 1µF MLCC (X5R)
*( ) TDFN2X2-6 Package

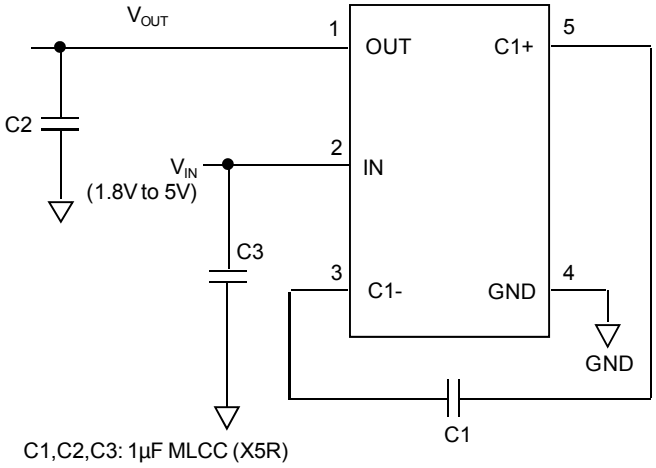
Pin Configuration (Continued)

G5930A



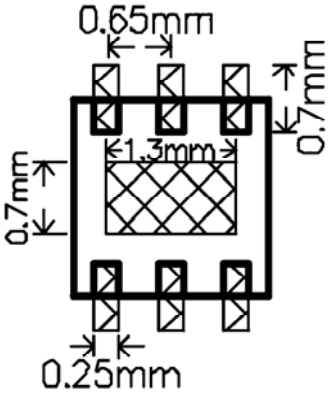
SOT-23-5

Typical Application Circuit (Continued)

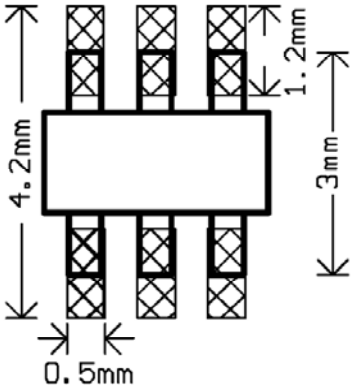


Minimum Footprint PCB Layout Section

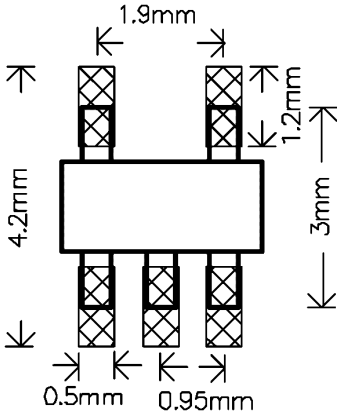
TDFN2X2-6



SOT-23-6



SOT-23-5



Absolute Maximum Ratings

IN to GND Voltage Range . . . . . .-0.3V to +5.5V
OUT to GND Voltage Range . . . . . .-5.5V to +0.3V
C1+ to GND Voltage Range . . . . . -0.3V to (V_{IN}+0.3V)
C1- to GND Voltage Range . . . . . (V_{OUT} -0.3V) to +0.3V
$\overline{SHDN}$ to GND Voltage Range . . . -0.3V to (V_{IN}+0.3V)
Operating Temperature Range . .. . -40°C to 85°C
OUT Short Circuit to GND . . . . . Indefinite
Thermal Resistance Junction to Ambient, (θ_{JA})*
SOT-23-6. . . . . 240°C/W
TDFN2X2-6 . . . . . 225°C/W
SOT-23-5 . . . . . 240°C/W

Continuous Power Dissipation (T_A = +25°C)*
SOT-23-6 . . . . . .0.521W
TDFN2X2-6 . . . . . .0.556W
SOT-23-5 . . . . . .0.521W
Thermal Resistance Junction to Case, (θ_{Jc})
SOT-23-6 . . . . . 80°C/W
TDFN2X2-6 . . . . . 75°C/W
SOT-23-5 . . . . . 80°C/W
Storage Temperature . . . . . -65°C to 150°C
Junction Temperature . . . . . .150°C
Reflow Temperature (soldering, 10sec) . . . . . 260°C
ESD Rating HBM 2000V

* Please refer to Minimum Footprint PCB Layout Section.

Note: Human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

Electrical Characteristics

V_{IN}=+3.3V, C1 = C2 = C3= 1μF, T_A= -40 to 85°C.

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage, V_{IN}	R_{LOAD}=10kΩ	1.8	---	5	V
Supply Current, I_Q	T_A=25°C	---	0.52	0.8	mA
Charge Pump Frequency, F_{SW}	V_{IN}=5V	200	270	330	kHz
Output Resistance(Note)	I_{LOAD}=10mA	---	8.3	---	Ω
Output Ripple	I_{LOAD}=5mA	---	14	---	mV p-p
	I_{LOAD}=25mA	---	56	---	mV p-p
Voltage Conversion Efficiency	No Load	99	---	---	%
Power Efficiency	I_{LOAD}=5mA	---	93	---	%
$\overline{SHDN}$ Input Logic High		0.7xV_{IN}	---	---	V
$\overline{SHDN}$ Input Logic Low		---	---	0.2	V

Electrical Characteristics

V_{IN}=+5V, C1 = C2 = C3= 1μF, T_A= -40 to 85°C.

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

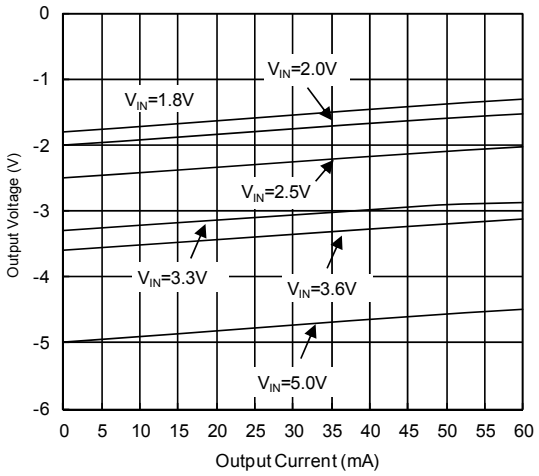
PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Supply Current, I_Q	T_A=25°C	---	1.29	1.8	mA
Charge Pump Frequency, F_{SW}	V_{IN}=5V	---	260	---	kHz
Output Resistance(Note)	I_{LOAD}=10mA	---	8.8	---	Ω
Output Ripple	I_{LOAD}=5mA	---	25	---	mV p-p
	I_{LOAD}=25mA	---	100	---	mV p-p
Voltage Conversion Efficiency	No Load	99	---	---	%
Power Efficiency	I_{LOAD}=10mA	---	90	---	%
$\overline{SHDN}$ Input Logic High		0.7xV_{IN}	---	---	V
$\overline{SHDN}$ Input Logic Low		---	---	0.2	V

Note: Capacitor contribution (ESR component plus (1/F_{SW}) · C) is approximately 20% of output.

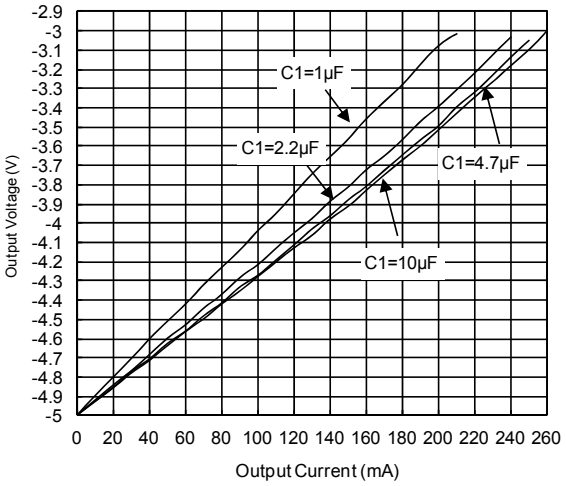
Typical Performance Characteristics

(V_{IN}=3.3V, C_1=C_2=C_3=1μF, T_A=25°C, unless otherwise noted.)

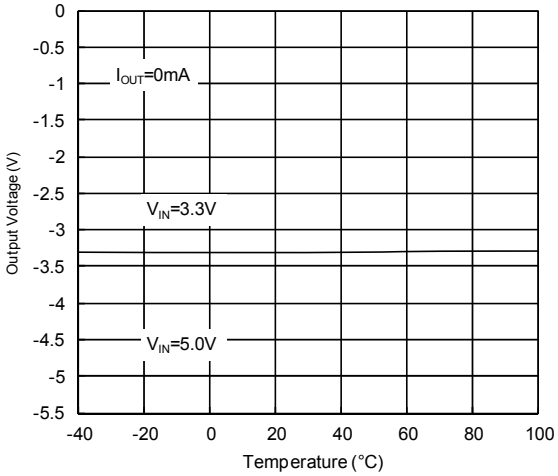
Output Voltage vs. Current



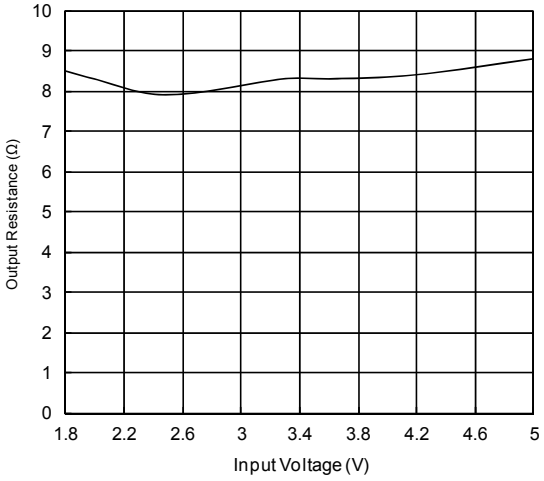
Output Voltage vs Output Current at V_{IN}=+5V



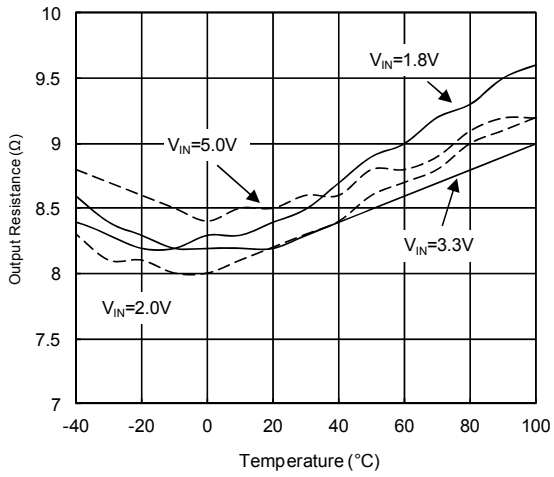
Output Voltage vs. Temperature



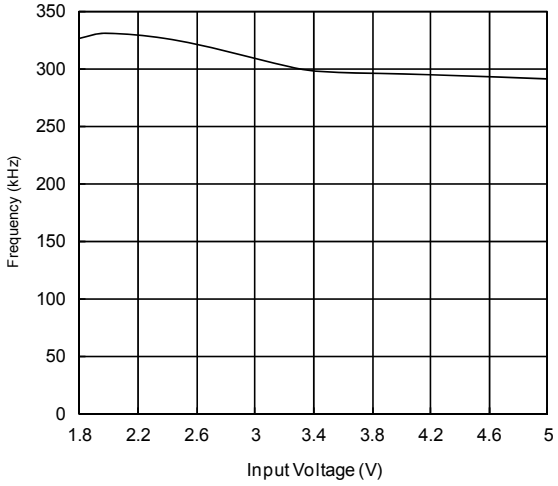
Output Resistance vs. Input Voltage



Output Resistance vs. Temperature

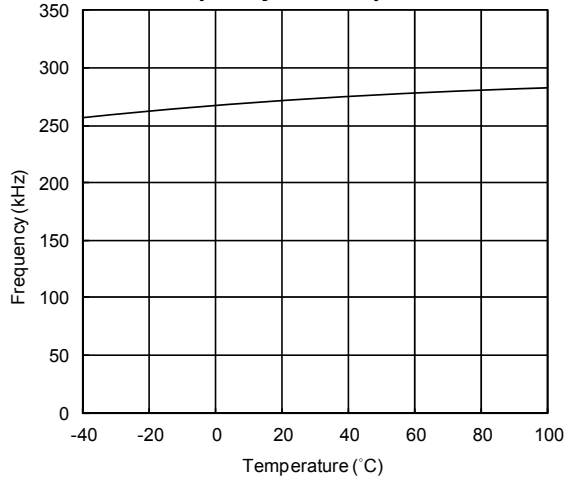


Frequency vs. Input Voltage

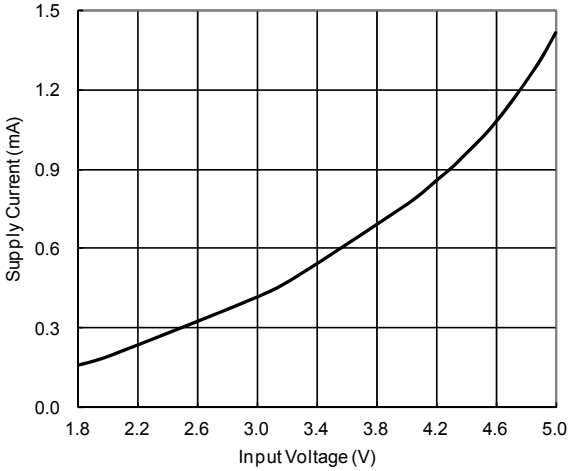


Typical Performance Characteristics (continued)

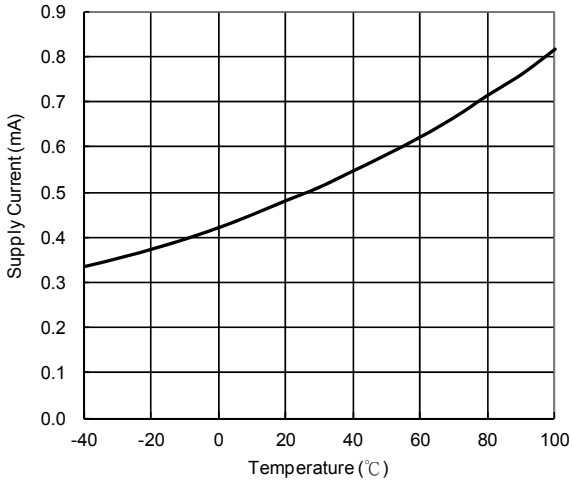
Frequency vs. Temperature



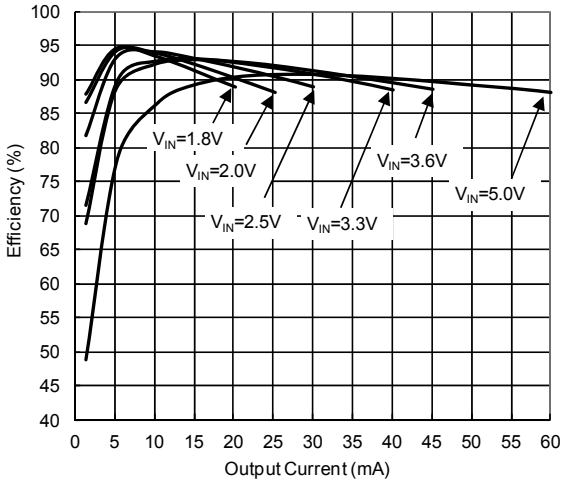
Supply Current vs. Input Voltage



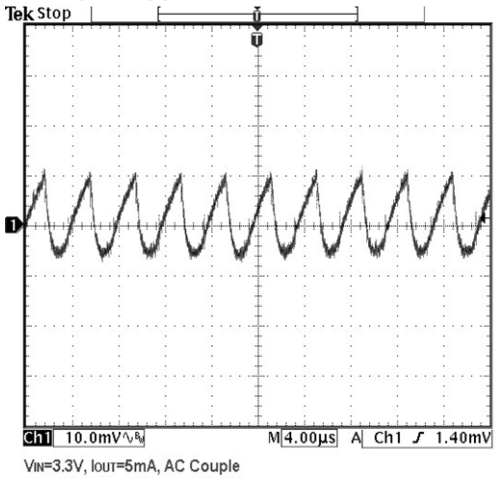
Supply Current vs. Temperature



Efficiency vs. Output Current

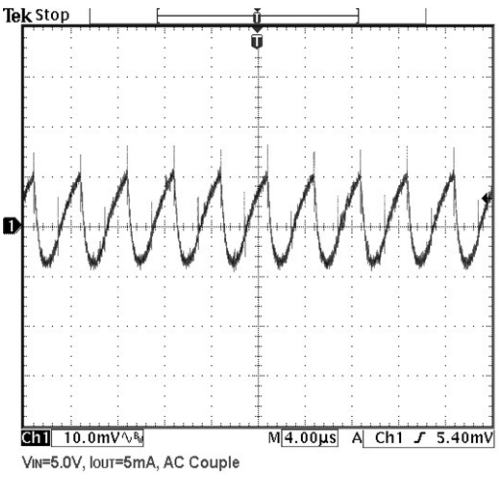


Output Ripple Waveform at V_{IN}=+3.3V



VIN=3.3V, IOUT=5mA, AC Couple

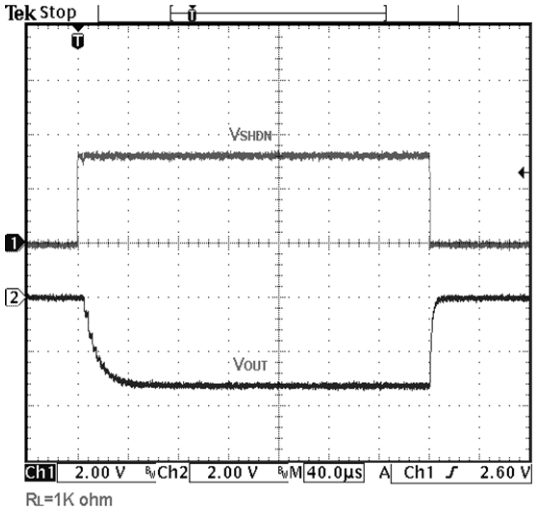
Output Ripple Waveform at V_{IN}=+5V



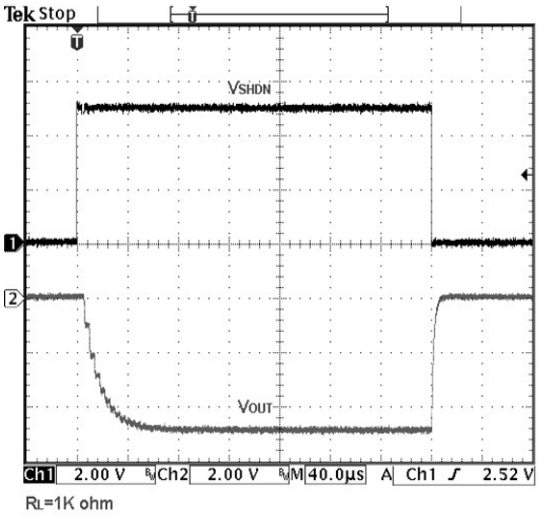
VIN=5.0V, IOUT=5mA, AC Couple

Typical Performance Characteristics (continued)

Startup From Shutdown-3.3V



Startup From Shutdown-5V



Pin Descriptions

PIN			NAME	FUNCTION
TDFN2X2-6	SOT-23-6	SOT-23-5		
1	2	2	IN	Power-Supply Positive Voltage Input
2	5	---	$\overline{SHDN}$	Inverting Shutdown Input
3	4	4	GND	Ground
4	3	3	C1-	Flying Capacitor's Negative Terminal
5	6	5	C1+	Flying Capacitor's Positive Terminal
6	1	1	OUT	Inverting Charge-Pump Output

Detailed Description

The G5930 contains four large switches which are switched in a sequence to inverter the input supply voltage. Energy transfer and storage are provided by external capacitors. Fig. 1 illustrates the voltage conversion scheme. When S1 and S3 are closed, C1 charges to the supply voltage $V_{IN.}$ During this time interval, switches S2 and S4 are open. In the second time interval, S1 and S3 are open; at the same time, S2 and S4 are closed, C1 is charging C2. After a number of cycles, the voltage across C2 will be pumped to V_{IN}. Since the anode of C2 is connected to ground, the output at the cathode of C2 equals $-(V_{IN})$ when there are no load current.

The G5930 has a logical-controlled shutdown input. Driving $\overline{SHDN}$ low places the G5930 in a low-power shutdown mode, and the charge pump switching halts. In the shutdown mode, supply current is smaller than 1μA. Besides, the OUT is activiely pulled to ground.

The main application of G5930 is to generate a negative supply voltage. The range of the input supply voltage is 1.8V to 5V. The output characteristics of this circuit can be approximated by an ideal voltage source in series with a resistance. The voltage source equals $-(V_{IN})$. The output resistance, Rout, is a function of the ON resistance of the internal MOSFET switches, the oscillator frequency, the capacitance and the ESR of both C_1 and C_2. Since the switching current charging and discharging C_1 is approximately twice as the output current, the effect of the ESR of the pumping capacitor C_1 will be multiplied by four in the output resistance. The output capacitor C_2 is charging and discharging at a current approximately equal to the output current, therefore, this ESR term only counts once in the output resistance. A good approximation of R_{out} is:

$$R_{OUT} \cong 2R_{SW} + \frac{2}{f_{OSC} x C_1} + 4ESR_{C1} + ESR_{C2}$$

Where R_{SW} is the sum of the ON resistance of the internal MOSFET switches shown in Figure 1.

High capacitance, low ESR capacitors will reduce the output resistance.

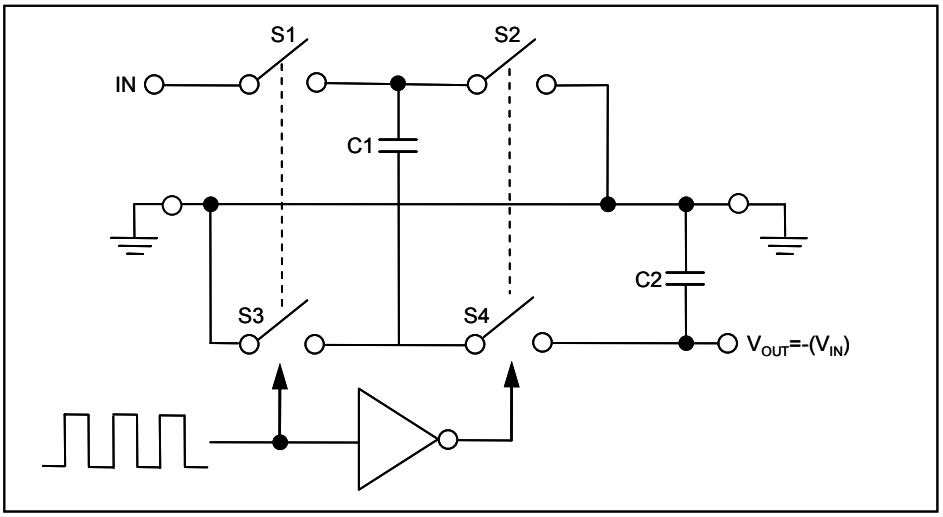


Figure 1. Ideal Voltage Inverter

Application Information

Table 1. Low-ESR Capacitor Manufacturers

PRODUCTION METHOD	MANUFACTURER	SERIES
Surface-Mount Ceramic	AVX	X7R
	Matsuo	X7R

Capacitor Selection

To maintain the lowest output resistance, use capacitors with low ESR (Table 1). The charge-pump output resistance is a function of C1's and C2's ESR. Therefore, minimizing the charge-pump capacitor's ESR minimizes the total output resistance.

Flying Capacitor (C1)

Increasing the flying capacitor's value reduces the output resistance. Above a certain point, increasing C1's capacitance has a negligible effect because the output resistance becomes dominated by the internal switch resistance and capacitor ESR.

Output Capacitor (C2)

Increasing the output capacitor's value reduces the output ripple voltage. Decreasing its ESR reduces both output resistance and ripple. Lower capacitance values can be used with light loads if higher output ripple can be tolerated. Use the following equation to calculate the peak-to-peak ripple:

$$V_{RIPPLE} = \frac{I_L}{f_{OSC} x C2} + 2 x I_L + ESR_{C2}$$

The output resistance is dependent on the capacitance and ESR values of the external capacitors. The output voltage drop is the load current times the output resistance, and the power efficiency is

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{I_L{}^2 R_L}{I_L{}^2 R_L + I_L{}^2 R_{OUT} + I_Q(V_{IN})}$$

Where $I_Q(V_{IN})$ is the quiescent power loss of the IC device,and $I_L{}^2R_{out}$ is the conversion loss associated with the switch on-resistance, the two external capacitors and their ESRs.

Input Bypass Capacitor (C3)

Bypass the incoming supply to reduce its AC impedance and the impact of the G5930's switching noise. A bypass capacitor with a value equal to that of C1 is recommended.

Voltage Inverter

The most common application for these devices is a charge-pump voltage inverter (Figure 2). This application requires only two external components— capacitors C1 and C2—plus a bypass capacitor, if necessary.

Layout and Grounding

Good layout is important, primarily for good noise performance. To ensure good layout, mount all components as close together as possible, keep traces short to minimize parasitic inductance and capacitance, and use a ground plane.

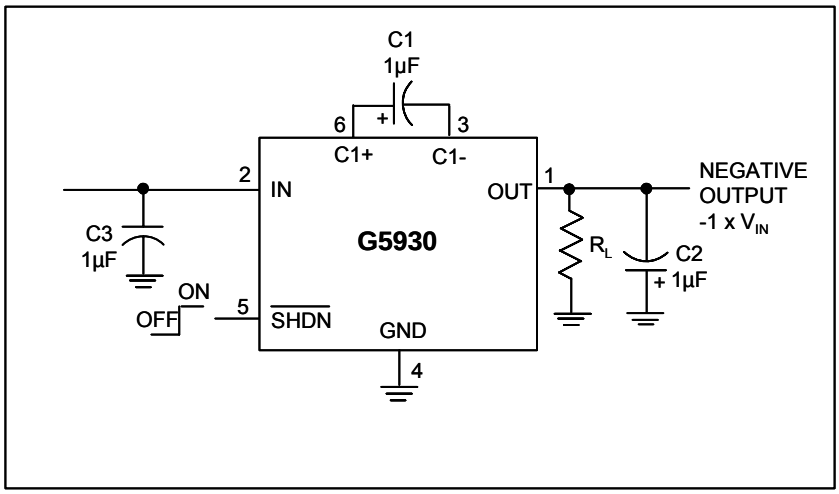
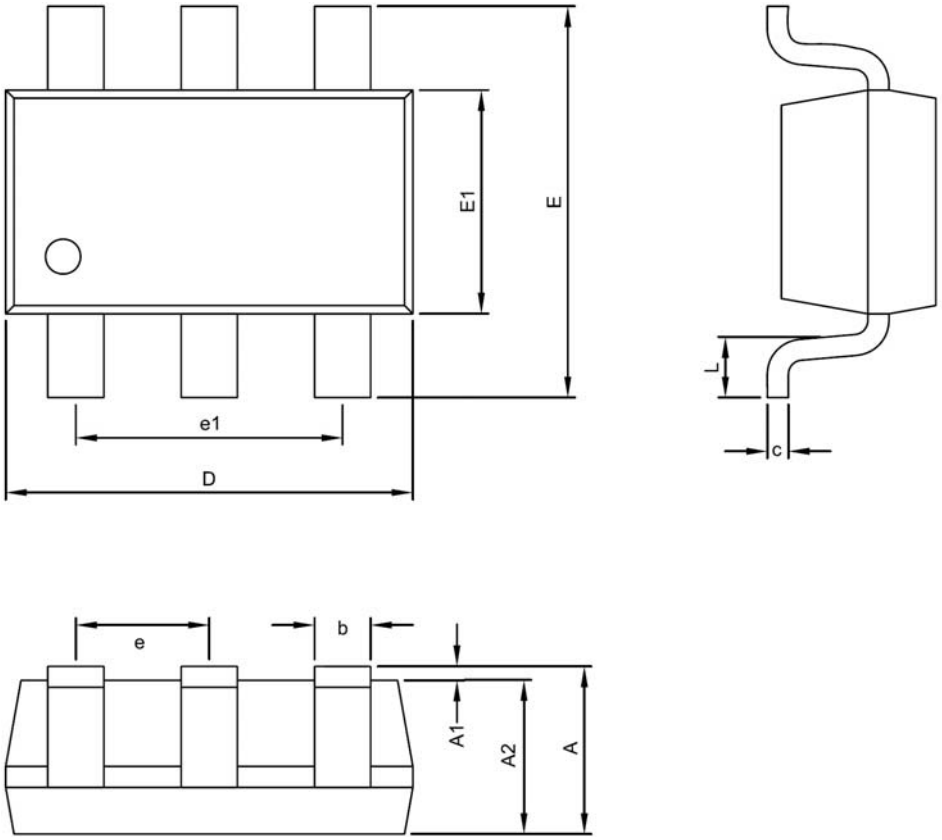


Figure 2. Typical Application Circuit

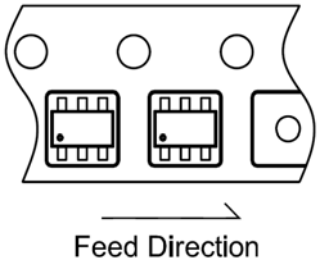
Package Information



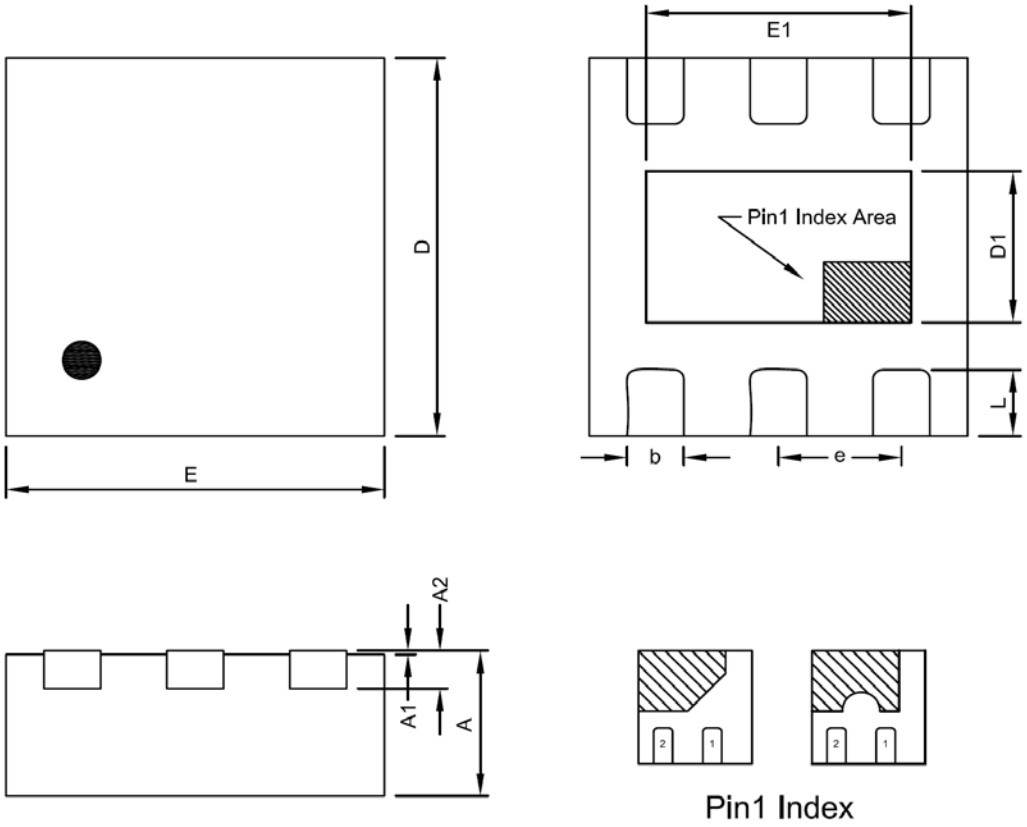
SOT-23-6 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.95	1.10	1.45	0.037	0.043	0.057
A1	0.00	---	0.15	0.000	---	0.006
A2	0.90	1.10	1.30	0.035	0.043	0.051
D	2.70	2.90	3.10	0.106	0.114	0.122
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
c	0.08	0.15	0.25	0.003	0.006	0.010
b	0.30	0.40	0.50	0.012	0.016	0.020
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
L	0.30	0.45	0.60	0.012	0.018	0.024

Taping Specification



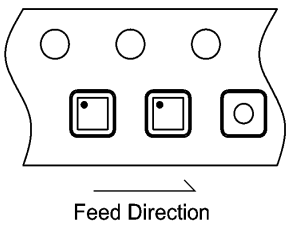
PACKAGE	Q'TY/REEL
SOT-23-6	3,000 ea



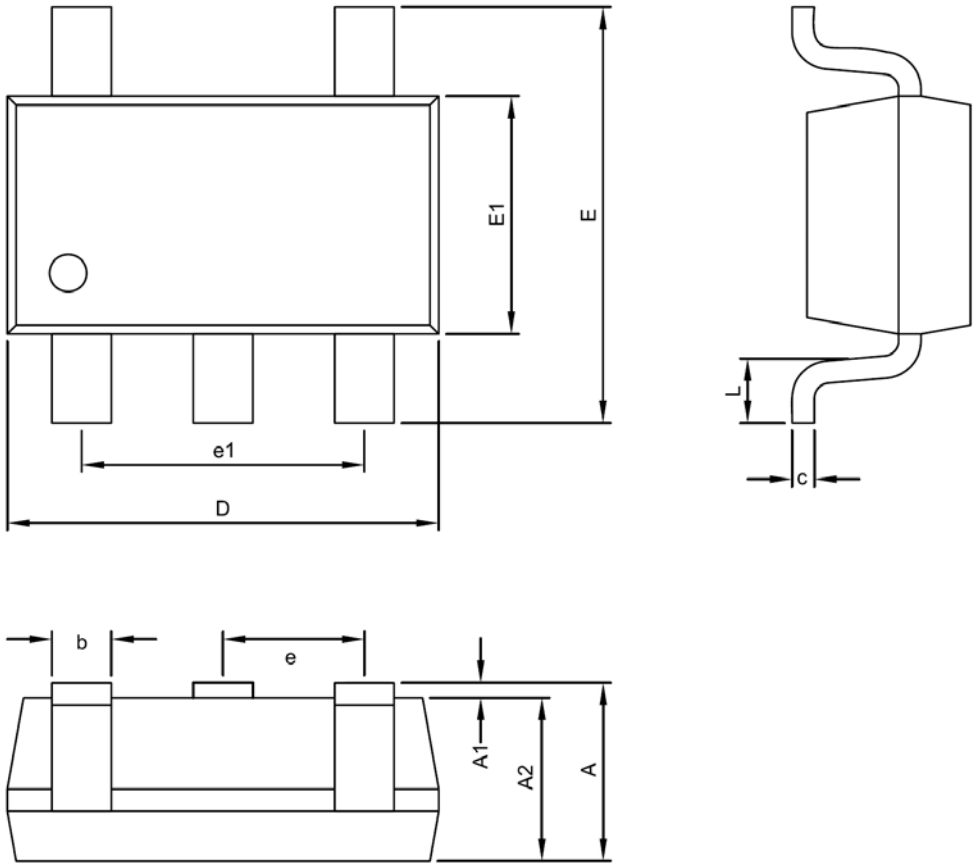
TDFN2X2-6 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079 REF		
D	1.95	2.00	2.05	0.0768	0.0787	0.0807
E	1.95	2.00	2.05	0.0768	0.0787	0.0807
D1	0.55	0.70	0.85	0.0217	0.0276	0.0335
E1	1.15	1.30	1.45	0.0453	0.0512	0.0571
b	0.20	0.30	0.35	0.0079	0.0118	0.0138
e	0.65 BSC			0.0256 BSC		
L	0.30	0.35	0.40	0.0118	0.0138	0.0157

Taping Specification



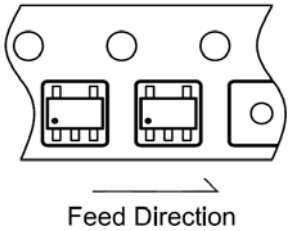
PACKAGE	Q'TY/REEL
TDFN2X2-6	3,000 ea



SOT-23-5 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.95	1.10	1.45	0.037	0.043	0.057
A1	0.00	---	0.15	0.000	---	0.006
A2	0.90	1.10	1.30	0.035	0.043	0.051
D	2.70	2.90	3.10	0.106	0.114	0.122
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
c	0.08	0.15	0.25	0.003	0.006	0.010
b	0.30	0.40	0.50	0.012	0.016	0.020
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
L	0.30	0.45	0.60	0.012	0.018	0.024

Taping Specification



PACKAGE	Q'TY/REEL
SOT-23-5	3,000 ea