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FAN5660

Monolithic Inductorless CMOS DC/DC Converter

Features

- Inverts, Doubles or Splits Input Supply Voltage
- 90% Typ Conversion Efficiency at 100mA load current
- 0.5V Typ Loss at 100mA Load
- Low 160µA Operating Current
- 5.0Ω Typ Output Resistance for C1 = C2 = 100µF
- Selectable Oscillator Frequency: 5kHz/50kHz
- 8-pin SOIC package.

Applications

- Laptop Computers
- Medical Instruments
- Interface Power Supplies
- Hand-Held Instruments
- Operational-Amplifier Power Supplies

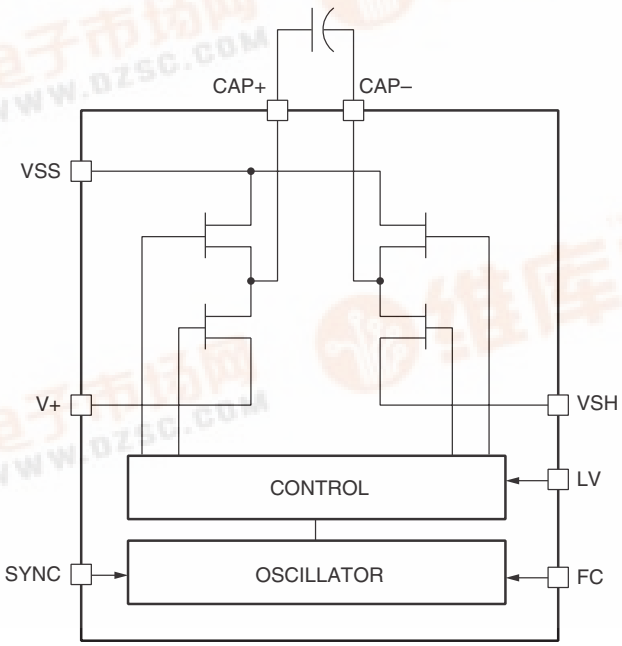
General Description

The FAN5660 is a monolithic charge-pump which can invert, double or split a +1.5V to +5.5V input voltage. Using only two identical low-cost capacitors, the charge pump replaces switching regulators, thus eliminating inductors and their associated cost, size, and EMI. The device has a greater than 90% efficiency over most of its load current range and a typical operating current of only 160µA. The FAN5660 is ideal for both battery-powered and board-level voltage conversion applications.

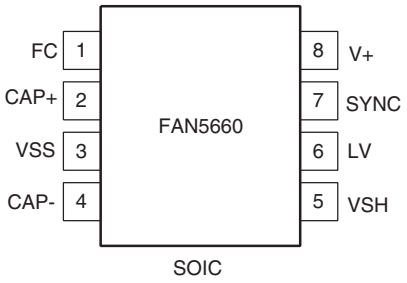
In order to enable the user optimize capacitor size and quiescent current, the FAN5660 is offered with a frequency control (FC) pin which selects either 5kHz or 50kHz operation.

The Oscillator frequency can also be driven with an external clock. The FAN5660 is available in 8-pin small-outline packages.

Simplified Block Diagram



Pin Configuration



Typical Applications

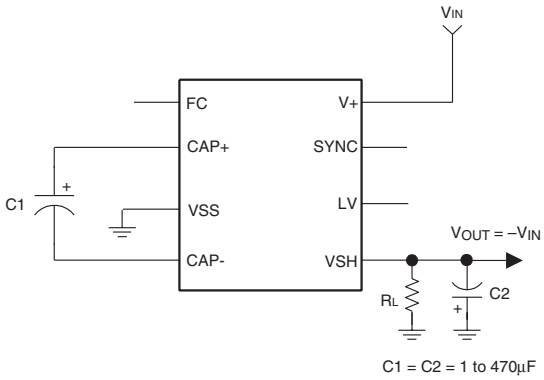


Figure 1. Inverter, Test Circuit

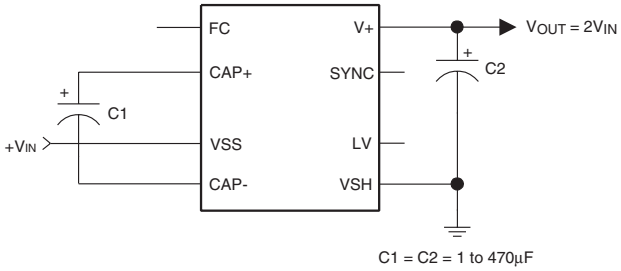


Figure 2. Doubler

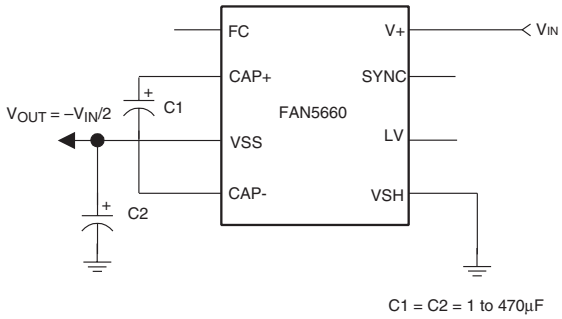


Figure 3. Splitter

Pin Definition

Pin Number	Pin Name	Pin Function Description		
		Inverter	Splitter	Doubler
1	FC	Frequency Control for Internal Oscillator, FC open, f_{OSC} = 5kHz typ; FC = V+, f_{OSC} = 50kHz typ. FC has no effect when SYNC pin is driven externally	Same as Inverter	Same as Inverter
2	CAP+	Charge-Pump Capacitor, Positive Terminal	Same as Inverter	Same as Inverter
3	VSS	Power-Supply Ground Input	Power-Supply Positive Voltage Output	Power-Supply Positive Voltage Input
4	CAP-	Charge-Pump Capacitor, Negative Terminal	Same as Inverter	Same as Inverter
5	VSH	Output, Negative Voltage	Power-Supply Ground Input	Power-Supply Ground Input
6	LV	Low-Voltage Operation Input. Tie LV to VSS when input voltage is less than 2V. Above 2V, LV must be left open.	LV must be left open for all input voltages	LV must be left open for all input voltages
7	SYNC	Oscillator Control Input. An external Oscillator may be connected to overdrive SYNC via a 2 to 5 nF capacitor. SYNC shall not be connected to a low impedance DC voltage	Same as inverter, however, do not use SYNC in voltage-splitting mode.	Same as inverter, however, do not use SYNC in voltage-doubling mode.
8	V+	Power-Supply Positive Voltage Input	Positive Voltage Input	Positive Voltage Output

Absolute Maximum Ratings

Absolute maximum ratings are the values beyond which the device may be damaged or have its useful life impaired. Functional operation under these conditions is not implied.

Parameter	Min.	Max.	Units
Supply Voltage: V+ to VSS	-0.3	6	V
VSH Voltage to VSS	-6	0.3	V
Voltage on all other pin to VSS	-0.3	(V+) + 0.3	V
VSH and V+ Continuous Output Current (**Note 1**)		120	mA
Junction Temperature		125	°C
Storage Temperature	-40	150	°C
Lead Soldering Temperature, 10 seconds		300	°C
Electrostatic Discharge Protection (**Note 2**)	4		kV
Power Dissipation (P_D) at 85C		300	mW

Notes

1. VSH must not be shorted to VSS or V+, even instantaeously, or device damage may result.
2. Using Mil Std. 883E, method 3015.7(Human Body Model), 400V when using JEDEC method A115-A (Machine Model).

Recommended Operating Conditions

Parameter	Conditions	Min.	Typ.	Max.	Units
Supply Voltage V+ to VSS or VSS to VSH	LV open	2		5.5	V
	LV = VSS	1.5		2	
External SYNC signal	Connected via C =2 to 5 nF		2		V peak to peak
Ambient Operating Temperature	T_A	-40		85	°C

Electrical Specifications

V+ = 5V, $R_L = \infty$, and T_A = +25°C using circuit in Figure 1 with C1 = C2 = 100µF, FC and LV open, unless otherwise specified (Note 3)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Quiescent Current	I_{IN}	FC open		0.16	0.5	mA
		FC to V+		1	2	
Output Current	I_{VSH}	VSH more negative than -4V	100			mA
Output Resistance	R_{VSH}	100mA load current		5	8	Ω
Oscillator Frequency	f_{OSC}	FC open	2.5	5	10	kHz
		FC to V+	30	50	90	
Power Efficiency	η	RL=1kΩ	96	98		%
		RL=0.5kΩ	92	96		
		100mA load current		90		
Voltage Conversion Efficiency	ηV		99	99.96		%

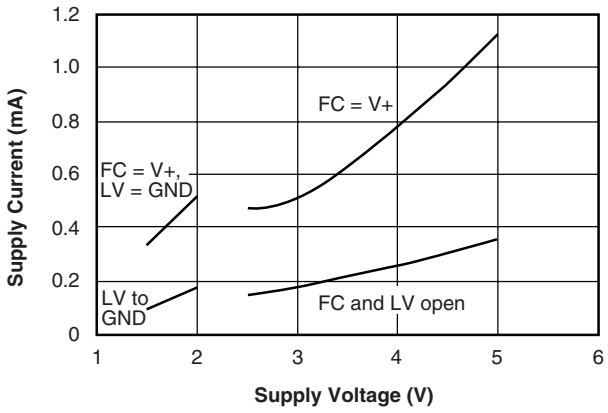
Note

3 . In the test circuit, capacitors C1 and C2 are 0.2Ω maximum ESR capacitors. Capacitors with higher ESR will increase output resistance, reduce output voltage and efficiency.

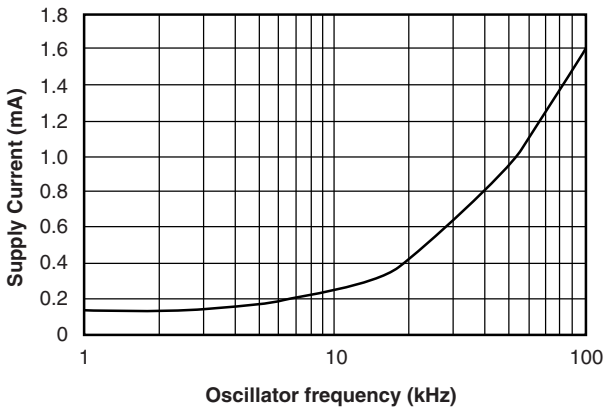
Typical Applications Diagrams

Unless otherwise specified T_A=25°C,V+=5V, C1=C2=100µF, Iload=0, FC and LV open, using circuit in Figure 1

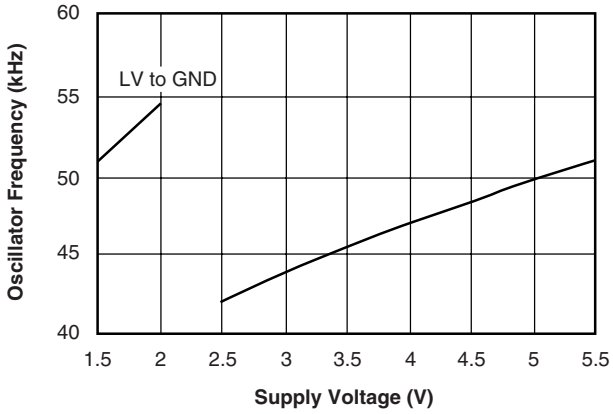
Supply Current vs. Supply Voltage



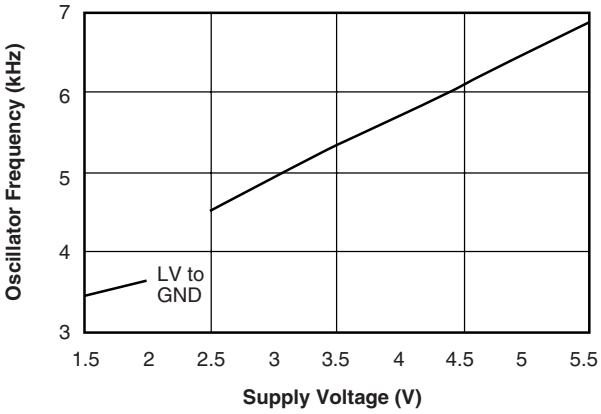
Supply Current vs. Oscillator Frequency



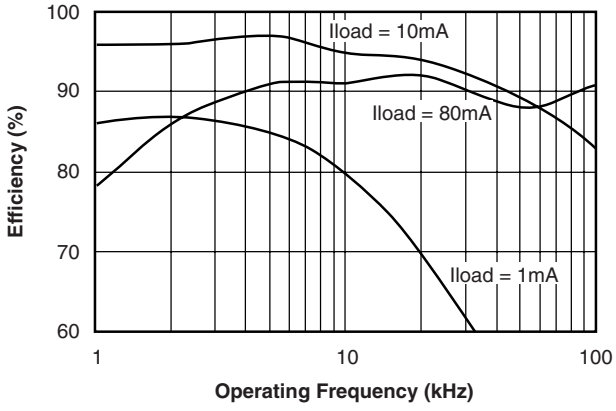
Oscillator Frequency vs. Supply Voltage, FC to V+



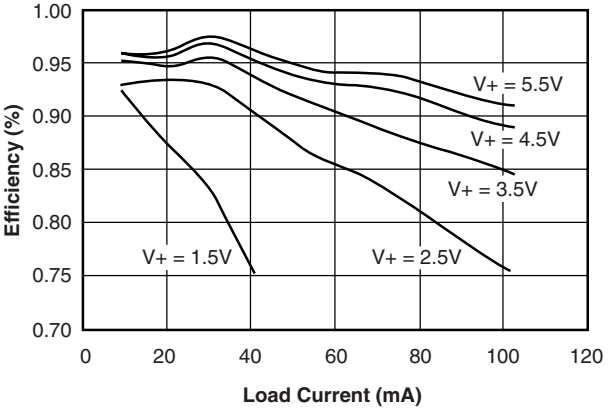
Oscillator Frequency vs. Supply Voltage



Efficiency vs. Operating Frequency

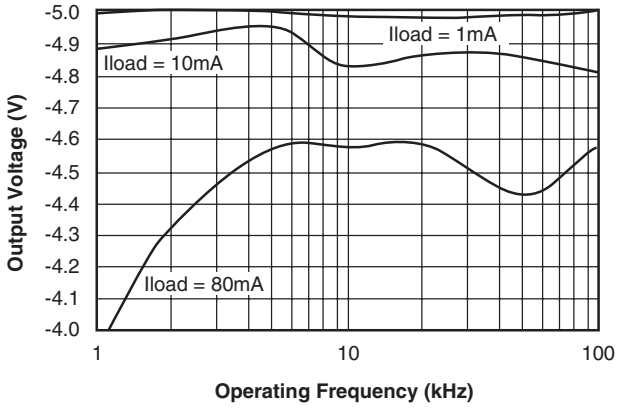


Efficiency vs. Load Current

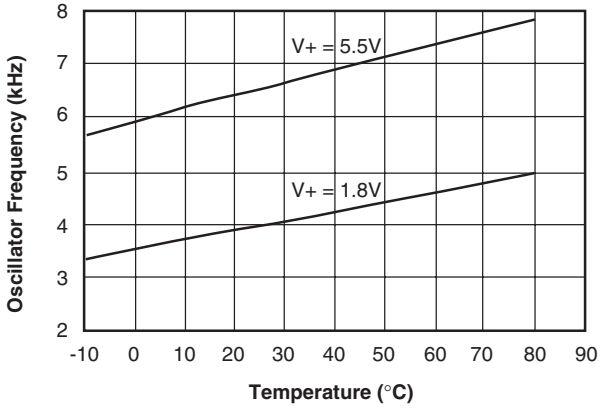


Typical Applications Diagrams (continued)

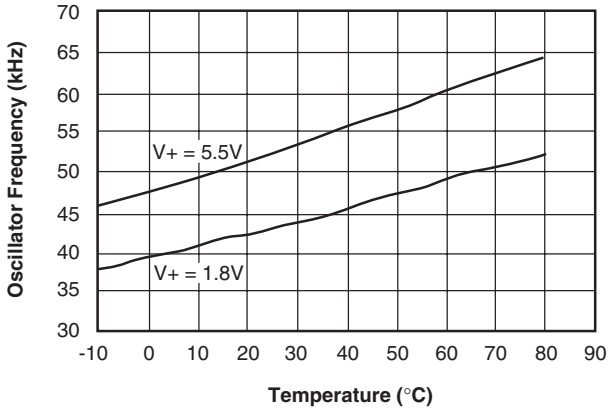
Output Voltage vs. Frequency



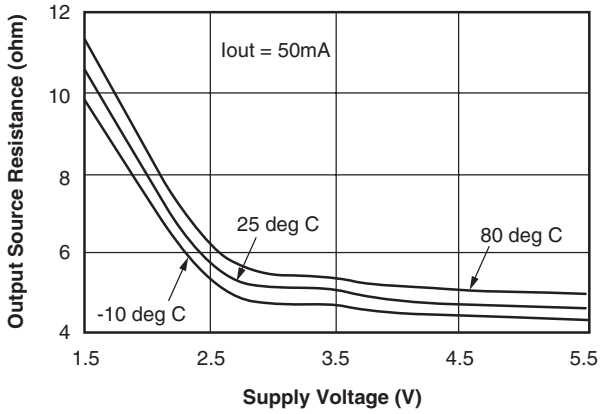
Oscillator Frequency vs. Temperature



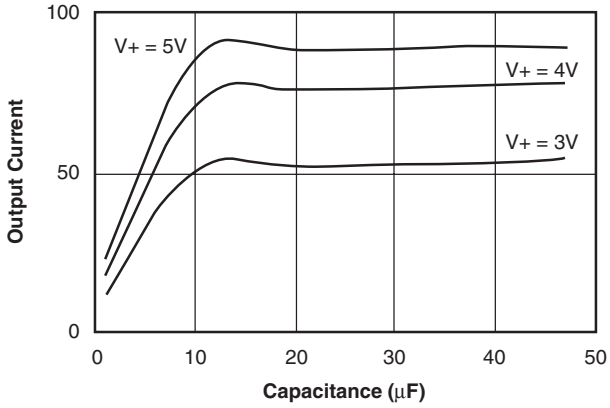
Oscillator Frequency vs. Temperature, FC to Vin



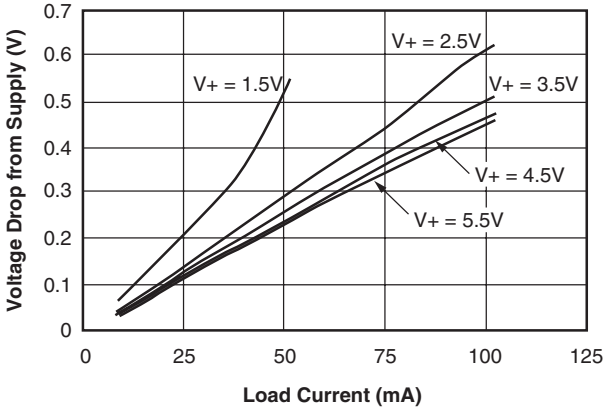
Output Source Resistance vs. Supply Voltage



Output Current vs. Capacitance (at Voltage Efficiency = 90%)



Output Voltage Drop vs. Load Current



Application Information

The FAN5660 capacitive charge pump circuit either inverts, splits or doubles the input voltage (see Typical Applications). For highest performance, capacitors with low effective series resistance (ESR) should be used (see Capacitor Selection section for more details). When using the inverting mode with a supply voltage less than 2V, LV may be connected to VSS. This bypasses the internal regulator circuitry and provides best performance in low-voltage applications. When using the inverter mode with a supply voltage above 2V, LV must be left open.

Negative Voltage Converter

The most common application of the FAN5660 is as a charge pump voltage inverter. The operating circuit uses only two identical external capacitors, C1 and C2 (see Typical Circuits). Even though its output is not actively regulated, the FAN5660 is very insensitive to load current changes. A typical output source resistance of 5Ω means that with an input of +5V the output voltage is -5V under light load, and decreases only to 4.5V with a load of 100mA.

Capacitors selection

Low ESR capacitors should be used at the output of FAN5660 to minimize output ripple, output resistance and to maximize efficiency. This can be achieved using ceramic capacitors, but certain types of tantalum capacitors may be sufficient. Output ripple voltage is calculated observing that the output current is solely supplied from capacitor C2 during one-half of the charge-pump cycle. This introduces a peak-to-peak ripple of:

$$V_{RIPPLE} = I_{VSH}/(2f \times C2) + I_{VSH} \times (ESR\ C2)$$

For example, for a nominal f= 5kHz and C2 = 100µF with an ESR of 0.05Ω, ripple is approximately 100mV with a 100mA load current. If C2 is raised to 470µF, the ripple drops to approximately 25mV.

Positive Voltage Doubler

The FAN5660 operates in the voltage-doubling mode as shown in Figure 2. The no-load output is $2 \times V_{IN}$.

Positive Voltage Splitter

The FAN5660 operates in voltage splitting mode as shown Figure 3. The no-load output is $V_{IN}/2$.

Changing Oscillator Frequency

Three modes control the FAN5660's clock frequency, as listed below:

FC	SYNC	Oscillator frequency
Open	Open	5kHz
FC = V+	Open	50kHz
Open	External Clock	External Clock Frequency

When FC and SYNC are unconnected (open), the Oscillator runs at 5kHz. When FC is connected to V+, the Oscillator frequency increases 10 times. In the inverter mode, SYNC may also be overdriven by an external clock source. A square wave signal of 2V peak-to-peak typical may be applied to SYNC via a 2 to 5nF capacitor to overdrive the internal oscillator. When SYNC is overdriven, FC has no effect. In some applications, the 5kHz output ripple frequency may be low enough to interfere with other circuitry. If desired, the Oscillator frequency can then be increased through use of the FC pin or an external Oscillator as described above. Increasing the clock frequency increases the FAN5660's quiescent current, but also allows smaller capacitance value to be used for C1 and C2.

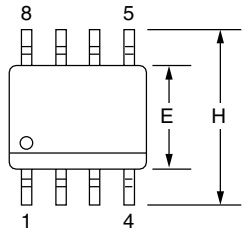
Package Dimensions

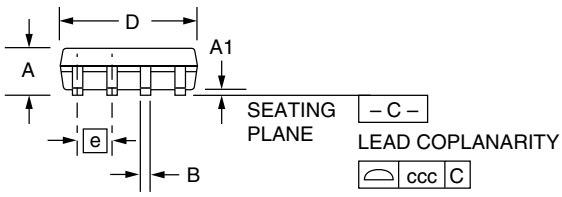
8-Pin SOIC

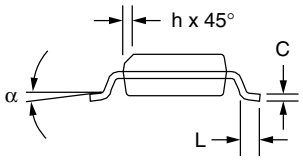
Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.053	.069	1.35	1.75	
A1	.004	.010	0.10	0.25	
B	.013	.020	0.33	0.51	
C	.0075	.010	0.20	0.25	5
D	.189	.197	4.80	5.00	2
E	.150	.158	3.81	4.01	2
e	.050 BSC		1.27 BSC		
H	.228	.244	5.79	6.20	
h	.010	.020	0.25	0.50	
L	.016	.050	0.40	1.27	3
N	8		8		6
α	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.







Ordering Information T_A = -40°C to +85°C

Part Number	Package
FAN5660IM	8-Pin SOIC,Tubes
FAN5660IMX	8-Pin SOIC, Tape and Reel