DESCRIPTION

Demonstration circuit 977 is a monolithic step-down DC/DC switching converter featuring the LT1976B. The LT1976B is the non-burst mode version of the LT1976 IC. The LT1976B operates down to zero load without burst mode resulting in the lowest ripple output over the full load current range. The board is optimized for 3.3V output at up to 1A load current for an input voltage range of 4V to 60V. *Minimum on-time restrictions and 3.3V output may limit the steady state maximum input voltage (above which pulse-skipping occurs) to 42V*. With its wide input voltage range, 1.2A internal power switch, 200kHz switching frequency, power good, soft start, shutdown, and sync features combined with a thermally enhanced package, the LT1976B is a very versatile and powerful IC. It is ideal for DC/DC converters that require high input voltage, compact space, high efficiency, and low output ripple.

The LT1976B 200kHz switching frequency allows all of the components to be small, surface mount devices. Synchronization with an external clock of up to 600kHz is possible. The current-mode control topology creates fast transient response and good loop stability with a minimum number of external components. The low saturation voltage internal power switch achieves high efficiencies of up to 85%. The $\overline{\text{SHDN}}$ pin can be used to program undervoltage lockout or place the part in micropower shutdown, reducing supply current to less than 1µA by driving the pin low. A power good comparator and a timing delay can be used for additional system diagnostics and sequencing. The soft start function reduces inrush current at soft start and output voltage overshoot.

The LT1976B datasheet gives a complete description of the part, operation and applications information. The datasheet must be read in conjunction with this Quick Start Guide for demonstration circuit 977. In particular, the datasheet section on ‘Thermal Calculations’ is important for estimating whether a given application’s combination of input voltage, load current and frequency will cause the LT1976B to exceed it’s absolute maximum rated junction temperature. The LT1976B is assembled in a small 16-pin thermally enhanced package with exposed pad where proper board layout is essential for maximum thermal performance. See the datasheet section ‘Layout Considerations’.

Design files for this circuit board are available. Call the LTC factory.

Table 1. Typical Performance Summary (T_A = 25°C)

PARAMETER	CONDITION	VALUE
Steady State Input Voltage Range	V_{OUT} = 3.3V, I_{OUT} ≤ 1A	4–42V
Maximum Transient Input Voltage		60V
V_{OUT}	V_{IN} = 4V to 42V, I_{OUT} ≤ 1A	3.3V ± 3%
Maximum Output Current	V_{OUT} = 3.3V	1A
Output Voltage Ripple	V_{IN} = 12V, I_{OUT} = 1A, V_{OUT} = 3.3V	24mV$_{PK–PK}$
	V_{IN} = 12V, I_{OUT} = 1mA, V_{OUT} = 3.3V	5mV$_{PK-PK}$
Switching Frequency	V_{IN} = 4V to 42V, I_{OUT} ≤ 1A	200kHz
Efficiency	V_{IN} = 12V, I_{OUT} = 1A, V_{OUT} = 3.3V	83%
	V_{IN} = 24V, I_{OUT} = 1A, V_{OUT} = 3.3V	80%

QUICK START PROCEDURE

Demonstration circuit 977 is easy to set up to evaluate the performance of the LT1976B. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

NOTE: Make sure that the input voltage does not exceed 60V.

NOTE: The synchronization, shutdown, and power good functions are optional and their terminals can be left floating (disconnected) if their functions are not being used.

NOTE: Do not hot-plug the input voltage terminal VIN. The absolute maximum voltage on VIN is 60V and hot-plugging a power supply through wire leads to the demonstration circuit can cause the voltage on the extremely low-ESR ceramic input capacitor to ring up to twice its DC value. This is due to high currents instantaneously generated in the inductive supply leads from an input voltage step on the low-ESR ceramic input capacitor. A bulky higher-ESR capacitor and an additional inductive filter can be added to the circuit to dampen hot-plug transient ringing. *See Application Note 88 for more details.* In order to protect the IC, a transient voltage suppressor diode can be added between VIN and GND terminals to absorb any high voltage transient ringing that may occur due to hot-plugging.

1. Connect the power supply (with power off), load, and meters as shown in Figure 1.
2. After all connections are made, turn on input power and verify that the output voltage is 3.3V.

   NOTE: If the output voltage is too low, temporarily disconnect the load to make sure that the load is not set too high.
3. Once the proper output voltages are established, adjust the load within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

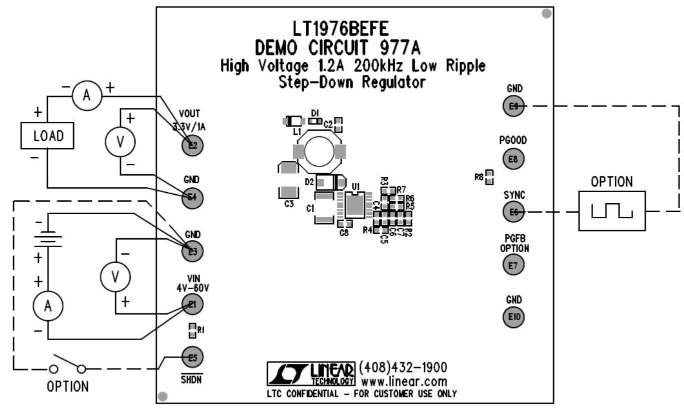


Figure 1. Proper Measurement Equipment Setup

FUNCTIONS & OPTIONS

OUTPUT VOLTAGE

The components assembled on the board are optimized for a wide input voltage range and a 3.3V output. The feedback resistors (R2, R3) can be changed to adjust the output voltage according to the following equation:

$V_{OUT} = 1.25\times(1 + R2/R5)$

For output voltages below 3V, the boost pin requires a higher voltage than the output can supply. In this case, an alternate source for boost such as the input voltage, a bias supply, or an external supply is required on the boost pin. Please see the datasheet for details.

For output voltages greater than 5V, the optional 'blocking' zener diode D3 can be used to reduce the boost voltage across C2 to some lower voltage between 3V and 5V. The diode D3 transfers power dissipation from inside the LT1976B to D3 on the demonstration circuit, outside the LT1976B, allowing higher ambient temperature operation of the part. Maintaining boost voltage between 3V and 5V maximizes efficiency and optimizes control of the power switch. It is recommended that a CMHZ5236B zener diode is used as D3 when V_{OUT} = 12V. To properly install D3, the small trace shorting the anode to the cathode of D3 on the board must be opened (an Exacto knife works well) ***before*** D3 is soldered to the board. The new value for boost voltage ($V_{OUT} - V_Z$) should be used when calculating junction temperature in the 'Thermal Calculations' section of the datasheet.

$P_{BOOST} = (V_{OUT} - V_Z)*V_{OUT}*(I_{OUT}/36)/V_{IN}$

POWER GOOD FEEDBACK OPTION

For systems that rely upon having a well-regulated power source or follow a particular power-up sequence, the LT1976 provides a power good flag with timed delay programmed by C8 when the power good feedback pin (PGFB) exceeds 90% of V_{REF} (1.25V). R3 (0 ohm short) ties PGFB and the feedback pin (FB) together. Therefore, the power good (PG) pin returns a 'good' signal when the output voltage has reached 90% of its final value.

The power good feedback pin can also be tied to the input voltage, an external source, or a resistor divider on any of these sources. Removing R3 breaks the connection between PGFB and FB.

The Power Good Feedback (PGFB Option) terminal is optional and is not stuffed on the board. The power good terminal node can be connected to the power good feedback (PGFB) pin by placing a 0Ω resistor in R7. The PGFB Option should be used when Power Good Feedback is required from a source other than the feedback pin. Be sure to remove the connection between PGFB and FB by removing R3 as mentioned above. Connect the desired Power Good Feedback source to the PGFB Option terminal and either short the terminal to PGFB pin with a 0Ω resistor in R7 or place a resistor divider from PGFB to GND with R7 and R6.

SHUTDOWN AND UNDERVOLTAGE LOCKOUT

The $\overline{\text{SHDN}}$ pin has a 200k pull-up resistor (R1) tied to V_{IN}. For normal operation, the SHDN terminal can be left floating. However, connecting the $\overline{\text{SHDN}}$ terminal to GND will place the IC in micropower shutdown. If the shutdown function is not being used, the pull-up resistor can be replaced with a 0Ω resistor.

For undervoltage lockout, the two-resistor divider network must be placed between V_{IN} and SHDN and between $\overline{\text{SHDN}}$ and GND. The top resistor can be placed in R1. The bottom resistor can be placed to the right of the SHDN terminal (the solder mask may have to be removed.

Please see the data sheet section '*Shutdown Function and Undervoltage Lockout*' for more details.

SOFT START

Soft start reduces the inrush current and limits output voltage overshoot by controlling the output voltage ramp-up rate. A single capacitor, C4, holds the peak current level clamp low, allowing it to slowly rise upon startup. When a short circuit, overload, or shutdown condition occurs, the soft start capacitor resets to zero and provides soft start during restart. Switchers that do not have soft start may transition from zero output to full output voltage while taking as much current as possible from the source and casting it into the output capacitor and load. This surge of current, only restricted by maximum peak switch current levels, can both drag down a battery source voltage and cause overshoot in the output voltage.

For the shortest possible startup time, remove the soft start capacitor from the circuit. Maximum inrush current can reach the level of 3A (the maximum switch current limit). Expect to see a significant increase in output voltage overshoot.

COMPENSATION

Demonstration Circuit 977 has a frequency compensation network that is optimized for the tantalum output capacitor C3, the wide input voltage range 4V to 60V (42V steady state), and 3.3V output. Improved loop bandwidth can be achieved for various output voltages, output capacitors, and input voltage ranges by adjusting R4, C5, C6, and C7. The feedforward capacitor (C7) is located in parallel with R2. Removing these components from the feedback loop may result in compromised loop stability. The use of alternate output capacitors such as ceramics or PosCaps may require changes to the compensation components. For more information, see the 'Frequency Compensation' section in the Applications Information in the datasheet, Application Note 19, or Application Note 76.

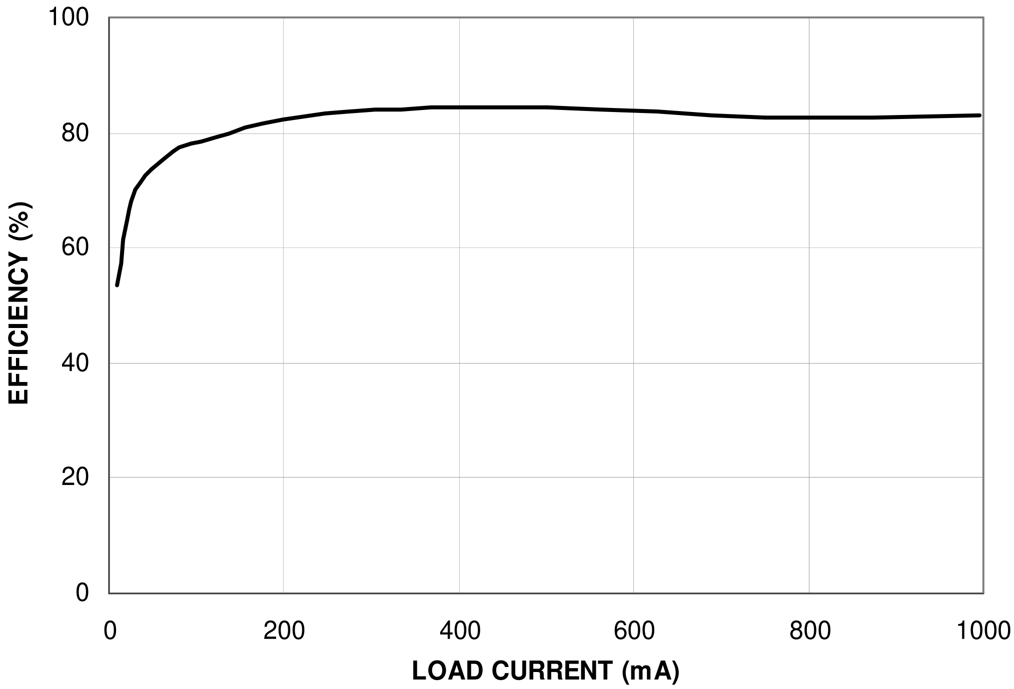


Figure 2. DC977 Typical Efficiency (T_A = 25°C, V_{OUT} = 3.3V)

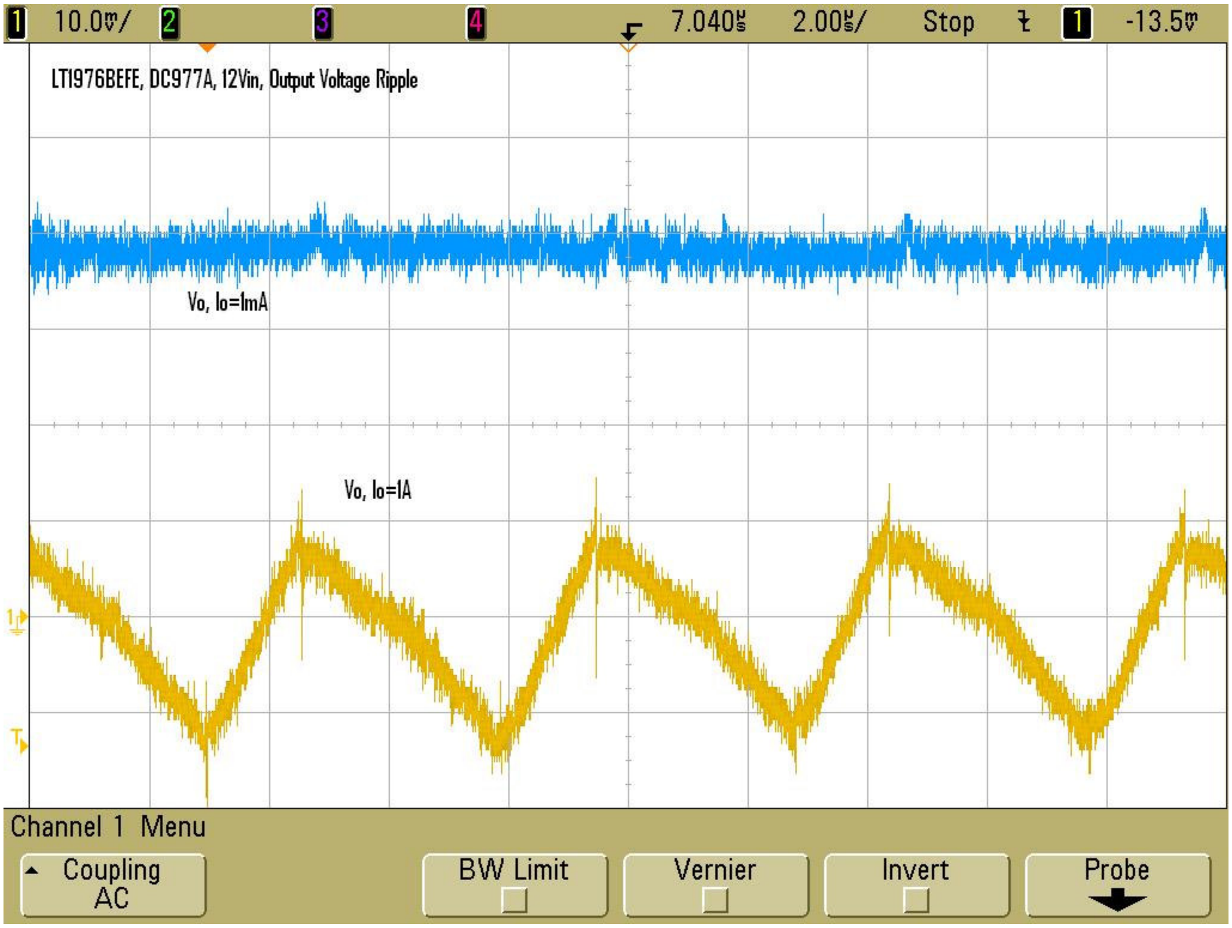
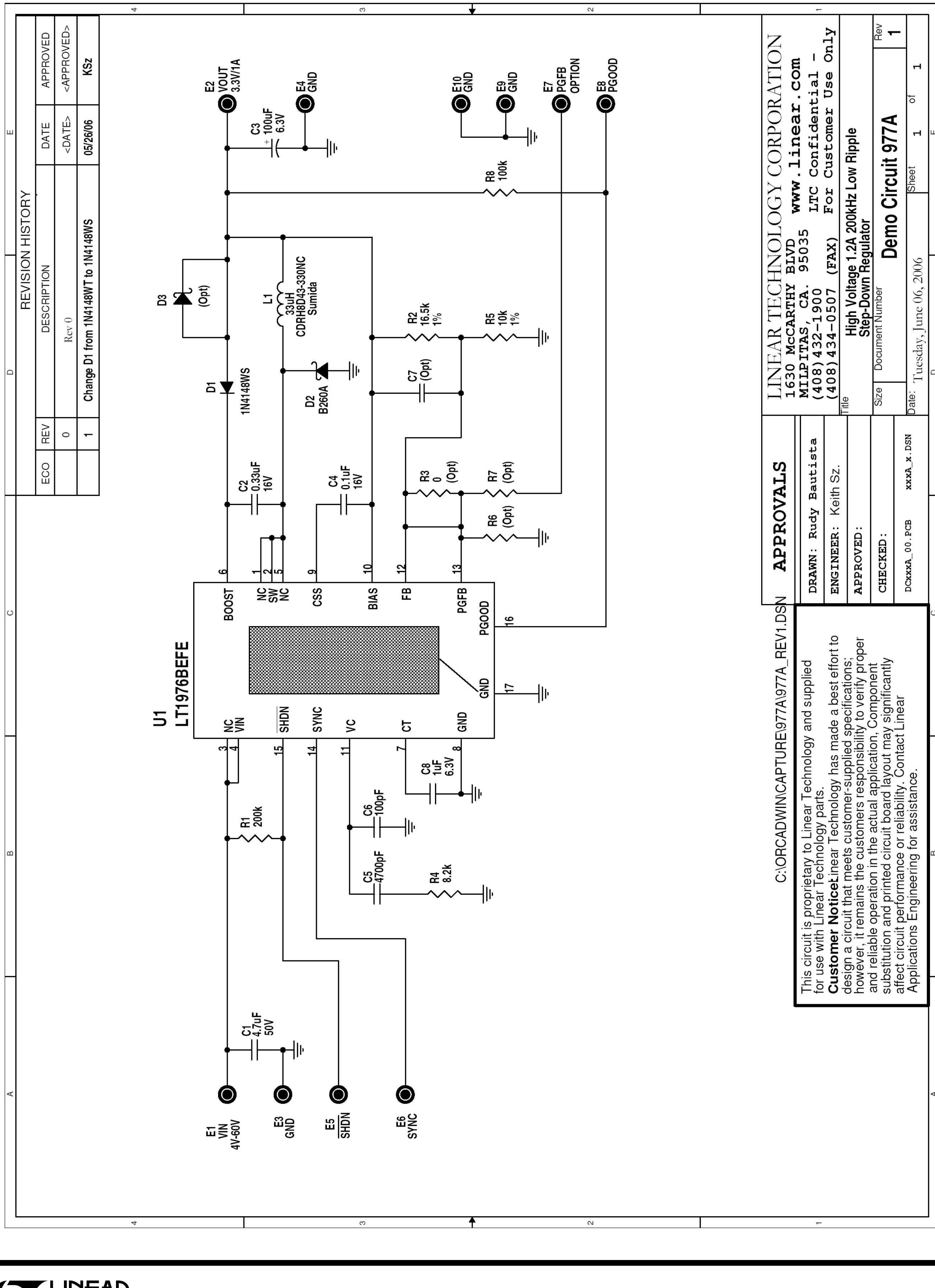


Figure 3. DC977 Typical Low Output Voltage Ripple (I_{OUT} = 1mA and 1A, V_{IN} = 12V, V_{OUT} = 3.3V, T_A = 25°C)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E6
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E2
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E10
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E9
GND
E7
PGFB
OPTION
E8
PGOOD
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50V
R1
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C5
4700pF
C6
100pF
R4
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APPROVALS
DRAWN: Rudy Bautista
ENGINEER: Keith Sz.
APPROVED:
CHECKED:
DCxxxA_00.PCB
xxxA_x.DSN
LINEAR TECHNOLOGY CORPORATION
1630 McCARTHY BLVD
MILPITAS, CA. 95035
(408)432-1900
(408)434-0507 (FAX)
www.linear.com
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