

# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT DC686

## HIGH EFFICIENCY STEP-UP/DOWN DC/DC CONVERTER

### LTC3780

## DESCRIPTION

Demonstration circuit 686, featuring the LTC3780, is a high efficiency step-up/down DC/DC converter that can regulate its output from input voltages both above and below the output. This board delivers 12V at 5 Amps from an input range of 5V to 32V.

The LTC3780 is a high performance buck-boost switching regulator controller designed to regulate outputs using input voltages above, below or equal to the output voltage. The constant frequency current mode architecture allows phase-lockable frequency of up to 400kHz. A wide input and output range with continuous transfer function through all operation modes, makes the product ideal for automotive, telecom and battery systems.

The LTC3780 is equipped with fault protection provided by an output overvoltage comparator and internal foldback current limiting. Soft-start control is accomplished with an external capacitor that controls the slew rate of the reference voltage for the error amplifier, which in turn controls the output slew rate of the regulator, and optional timed short-circuit shutdown. A Power Good output pin indicates when the output is within 7.5% of designed set point.

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

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**Table 1. Performance Summary ( $T_A = 25^\circ\text{C}$ )**

PARAMETER	CONDITION	VALUE
Load Regulation	$V_{in} = 32\text{V}$ , $V_{out} = 12\text{V}$ , 0 – 5A load	$\pm 2\%$
Line Regulation	$V_{in} = 5$ to 32V, $V_{out} = 12\text{V}$ , 5A load	$\pm 2\%$
Maximum Output Current	$V_{in} = 5 - 32\text{V}$ , $V_{out} = 12\text{V}$	5.0A
Full Load Efficiency @ 5Vin	$V_{in} = 5\text{V}$ , $V_{out}=12\text{V}$ , $I_o=5\text{A}$	90%
Full Load Efficiency @ 12Vin	$V_{in}=12\text{V}$ , $V_{out}=12\text{V}$ , $I_o=5\text{A}$	98%
Full Load Efficiency @ 32Vin	$V_{in} = 32\text{V}$ , $V_{out}=12\text{V}$ , $I_o=5\text{A}$	90%

### QUICK START PROCEDURE

Demonstration circuit 686 is easy to set up to evaluate the performance of the LTC3780. For proper equipment setup, follow the procedure below, referring to figure 1:

1. With the power source turned off, connect the input power supply to the board through the VIN+ (J1) and GND (J2) terminals.
2. Connect the load to the VOUT (J3) and GND (J4) terminals.
3. Set the RUN jumper at JP1 to the OFF position.
4. Position the STBY jumper at JP4 to the ON position for initial testing.
5. Set the FSET jumper at JP3 to the INT PROG position.
6. Position the switching mode jumper at JP2 to position A (BURST) for initial testing.
7. Turn on the input power source to at least 6V, but below 32V.
8. Change the RUN jumper at JP1 to the ON position.
9. Verify that the output voltage is 12V. If there is no output, temporarily disconnect the load to make sure that the load is not too high.
10. Once the proper output voltage is established, vary the input voltage and load within the given operating ranges and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

### OPERATION

Demonstration circuit 686, featuring the LTC3780, is able to regulate loads for input voltages below, equal to or above the output voltage. If the input voltage is below the output voltage, the LTC3780 acts as a boost controller. If the input is above the output, the LTC3780 acts as a buck controller. If the

input voltage is near the output, the LTC3780 behaves as a buck-boost. For a more detailed description of this operation and how the chip transitions from mode to mode, please refer to the LTC3780 data sheet.

Demonstration circuit 686 is configured to operate the LTC3780 at a switching frequency of 200kHz and regulate its output at 12VDC to a maximum load of 5A. It is possible to synchronize the switching frequency to an external source between 200kHz and 400kHz. To do so, move the jumper at JP3 to the EXT SYNC position and apply the external signal, preferably a square wave, to TP10 (SYNC). If synchronization is not required, the user can still vary the frequency by applying the JP3 jumper to the EXT SYNC position and applying 0.5V to 2V directly to the FSET terminal (TP9). The user should bear in mind that increasing the switching frequency also increases the switching losses and thus reduces the efficiency of the demonstration circuit.

The user may also configure the board to operate in one of three control modes – burst mode, discontinuous mode and constant current mode. These modes are activated by setting the JP2A, 2B, or 2C positions, labeled BURST for burst mode, DCM for discontinuous mode and CCM for constant current mode. These modes are discussed in detail in the LTC3780 data sheet. The user is cautioned, however, that continuous current mode allows the output to either sink or source current, which may raise the input voltage to undesirable levels.

TP3 is for monitoring only. Do not apply the load here, as damage may occur. Only apply the output load to the J3 and J4 power jacks.

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Other terminals are provided for monitoring. TP4 is used to examine the open drain PGOOD signal, which indicates that the output is within regulation. For purposes of demonstration, the PGOOD signal is pulled up through a 10K resistor to the on-board 6V, which may not be suitable for all systems. TP5 is attached to the soft start pin of the LTC3780. Please refer to the data sheet for detailed information on these two functions.

When power is applied, the LTC3780 becomes operational once the voltage exceeds 5.1V. If the full rated load of DC686 is present at the output when power is applied, the input will ramp up to almost 14A. If the output impedance of the power source or the wiring resistance is too high, the input voltage at the demonstration board will fall below the UVLO trip point on the LTC3780 and cause it to shut down the output. This will in turn cause the input current to fall and the input voltage to rise, turning on the LTC3780 again, resulting in a “motor-boat” behavior. Be careful to use a power supply with sufficient output current and connect it to DC686 with sufficiently low gauge wire.

When measuring switching waveforms on DC686, the user must keep the operating modes in mind. Suppose the user measures the waveform at the inductor. Depending on whether the operating mode is boost, buck-boost or buck, the 200kHz switching may appear on one or the other or both sides of the inductor.

Furthermore, as the LTC3780 must provide essentially 100% duty cycle to either Q3 or Q4 in boost or buck mode, the charge pump that provides voltage to these MOSFET gates must be refreshed. This refresh event occurs every 10 or so switching cycles and has the net effect of injecting a small delay between adjacent PWM pulses. The proper way to examine the switching waveforms is by synchronizing the oscilloscope to the refresh pulse

For example, if you want to examine the switching waveform at the inductor, apply probes to both sides. On one side, you will see the 200kHz switching waveform. On the other, you will see the refresh pulse at about  $1/10^{\text{th}}$  the frequency.

Synchronize the oscilloscope to the side of the inductor switching at the refresh pulse frequency.

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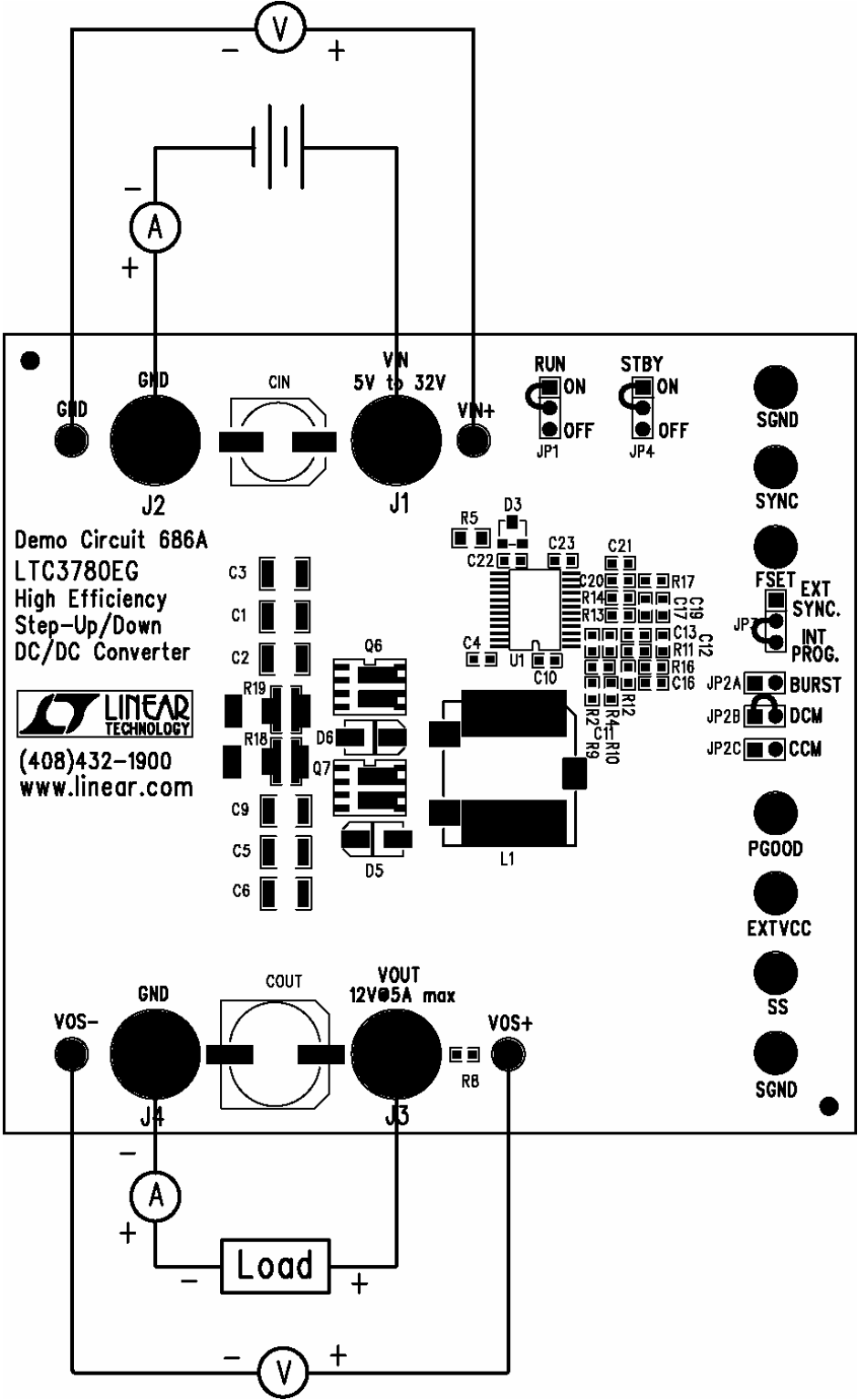
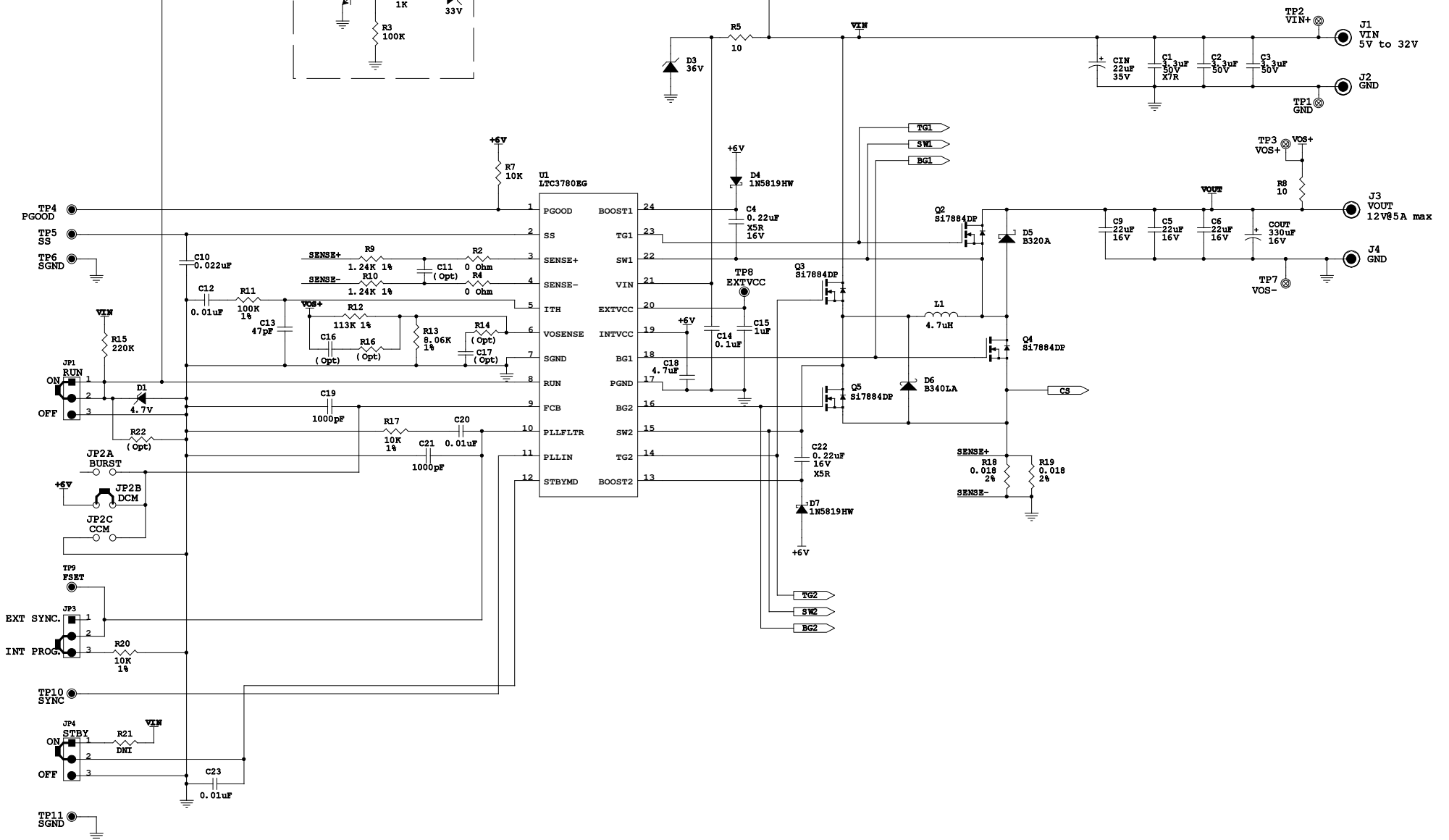
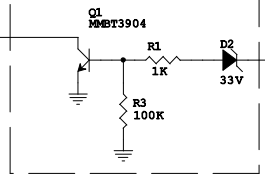


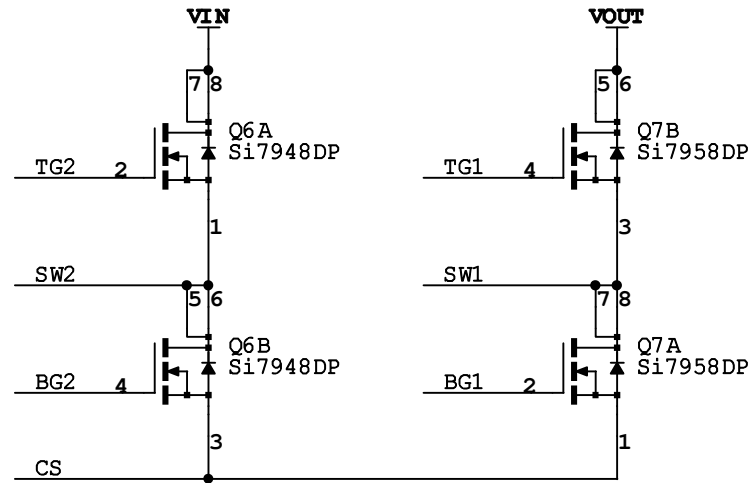
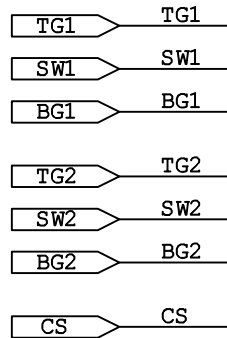
Figure 1. DC686 Test and Measurement Setup Diagram

Optional OV Shutdown



This circuit is proprietary to Linear Technology and supplied for use with Linear Technology parts.  
**Customer Notice:** Linear Technology has made a best effort to design a circuit that meets customer-supplied specifications; however, it remains the customer's responsibility to verify proper and reliable operation in the actual application. Component substitution and printed circuit board layout may significantly affect circuit performance or reliability. Contact Linear Applications Engineering for assistance.

# OPTIONAL CIRCUIT #1 (1.5A OUTPUT)



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