

# LTC3626EUDC

## 20V, 2.5A Synchronous Monolithic Step-Down Regulator with Current and Temperature Monitoring

### DESCRIPTION

Demonstration circuit 1768A is a step-down converter, using the LTC3626 monolithic synchronous buck regulator, which has current and temperature monitoring capabilities. The 1768A has an input voltage range of 3.6V to 20V, and is capable of delivering up to 2.5A of output current. The output voltage of the 1768A can be set as low as 0.6V, the reference voltage of the LTC3626. At light load currents, the 1768A is capable of operating in Burst Mode™, which makes for greater efficiency, and during shutdown, it consumes less than 2μA of quiescent current. In continuous mode operation, the 1768A is a high efficiency circuit over 90%. The 1768A can also track another voltage with the LTC3626

track function. Because of the current and temperature monitoring and limiting capabilities of the LTC3626, the 1768A input or output current, as well as its maximum temperature can be limited or clamped. The 1768A uses low profile surface mount components, due to the high switching frequency capability of the LTC3626, which is programmable up to 3MHz. All these features make the 1768A an ideal circuit for use in industrial applications.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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### PERFORMANCE SUMMARY

| PARAMETER   | CONDITIONS   | VALUE                                   |
|---|--|---|
| Input Voltage Range                                     |  | 3.6V – 20V                              |
| Output Voltage Range                                    |  | 0.6V–6V                                 |
| Run/Shutdown  |  | GND = Shutdown<br>V <sub>IN</sub> = Run |
| Output Voltage Regulation                               | V <sub>IN</sub> = 3.6V to 20V, I <sub>OUT</sub> = 0A to 2.5A                         | 1.2V ±2% Typ. (1.176V – 1.224V)         |
|   | V <sub>IN</sub> = 3.6V to 20V, I <sub>OUT</sub> = 0A to 2.5A                         | 1.8V ±2% Typ. (1.764V – 1.836V)         |
|   | V <sub>IN</sub> = 4V to 20V, I <sub>OUT</sub> = 0A to 2.5A                           | 3.3V ±2% Typ. (3.234V – 3.366V)         |
| Typical Output Ripple Voltage                           | V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.8V<br>I <sub>OUT</sub> = 2.5A (20MHz BW) | < 20mV <sub>p-p</sub>                   |
| Burst Mode-to-Continuous Mode Transition Current Values | V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.2V                                       | I <sub>OUT</sub> < 680mA                |
|   | V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.8V                                       | I <sub>OUT</sub> < 880mA                |
|   | V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 3.3V                                       | I <sub>OUT</sub> < 1.2A                 |
| Mode  | Mode Pin = INTV <sub>CC</sub>  | Burst Mode                              |
|   | Mode = GND   | FCM (Forced Continuous Mode)            |
|   | Mode = Floating  | Synchronized or Burst Mode              |
| Nominal Switching Frequency                             | R <sub>T</sub> = 324k  | 1MHz ±20%                               |
|   | R <sub>T</sub> connected to INTV <sub>CC</sub>                                       | 2MHz ±30%                               |

## QUICK START PROCEDURE

Demonstration Circuit 1768A is easy to set up to evaluate the performance of the LTC3626. For proper measurement equipment configuration, set up the circuit according to the diagram in Figure 1. Before proceeding to test, check that the shunts are inserted into the default locations: 1.2V position of the output voltage header JP1, the SS position of the soft-start/track header JP5, the FCM (Forced Continuous Mode) position of the MODE header JP6, the ON position of RUN header JP7, the 1MHz position of the frequency header JP8, the EXT position of the  $I_{TH}$  header JP9, the SET/OFF position of the temperature set header JP10, the OFF position of the temp. monitoring header JP11, the OFF position of the output current monitoring header JP12, and the OFF position of the input current monitoring header JP13.

When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the  $V_{IN}$  or  $V_{OUT}$  and GND terminals. See Figure 2 for proper scope probe measurement technique.

With the 1768A set up according to the proper measurement configuration and equipment in Figure 1, apply 6.3V at  $V_{IN}$  (Do not hot-plug  $V_{IN}$  or increase  $V_{IN}$  over the rated maximum supply voltage of 20V, or the part may be damaged.). Measure  $V_{OUT}$ ; it should read 1.2V (If desired, the quiescent current of the circuit can be monitored now by swapping the shunt in header JP7 into the OFF position.). The output voltage should be regulating. Measure  $V_{OUT}$  it should measure  $1.2V \pm 1\%$  (1.188V to 1.212V).

Vary the input voltage from 3.6V to 20V and adjust the load current from 0 to 2.5A.  $V_{OUT}$  should regulate around  $1.2V \pm 2\%$  (1.176V to 1.224V). Measure the output ripple voltage; it should measure less than 20mVAC. Set the input voltage to 12V and the output current to any current less than 1.25A. Observe the discontinuous mode of operation at the switch node, and measure the output ripple voltage. It should measure less than 50mV. Change the shunt position on the MODE header from BM to FCM (Forced Continuous Mode) and observe the voltage waveform at the switch pins (the other side of the inductor from the output). Verify the switching frequency is between 850kHz and 1.2MHz ( $T = 1.17\mu s$  and 833ns), and that the switch node waveform is rectangular in shape.

Insert the JP7 shunt into the OFF position and move the shunt in the 1.2V output JP1 header into any of the two remaining output voltage option headers: 1.8V (JP2) or 3.3V (JP3). Just as in the 1.2V  $V_{OUT}$  test, the output voltage should read  $V_{OUT} \pm 1\%$  tolerance under static line and load conditions and  $\pm 1\%$  tolerance under dynamic line and load conditions  $\pm 2\%$  total). Also, the circuit operation in discontinuous mode will be the same.

Monitor the input and output currents, and the die temperature, by changing the shunts on headers JP13, JP12, and JP11, respectively. The currents and temperature can even be limited using headers JP13, JP12, and JP10 – the TSET header, and adjusting the values of resistors R12, R13, and R14 (Consult the Input/Output Current and On-Die Temperature Monitor and Limit section of the LTC3626 datasheets for more details.).

When finished, turn off the circuit by inserting the shunt in header JP7 into the OFF position.

## QUICK START PROCEDURE

**Table 1. Jumper Description**

| JUMPER | FUNCTION  | RANGE/SETTING (DEFAULT) |
|--------|---|-------------------------|
| JP1    | Output Voltage Setting.   | 1.2V                    |
| JP5    | Soft-Start (TRACK or SS)  | TRACK – (SS)            |
| JP6    | MODE/SYNC: Forced Continuous Mode (FCM), Burst Mode, or SYNC  | (FCM) – BM – SYNC       |
| JP7    | RUN   | (ON) – OFF              |
| JP8    | Frequency (FREQ)  | (1MHz) – 2MHz           |
| JP9    | ITH: External Comp. (EXT) or Internal (INTV <sub>CC</sub> ) Comp. (INT)                                       | (EXT) – INT             |
| JP10   | Temperature Setting (TSET): Externally Set (EXT SET) or Internally Set (INTV <sub>CC</sub> ) or Off (SET/OFF) | EXT SET – (SET/OFF)     |
| JP11   | Temperature Monitoring (TMON)   | ON – (OFF)              |
| JP12   | Output Current Monitoring (I <sub>OUT</sub> )   | ON – (OFF)              |
| JP13   | Input Current Monitoring (I <sub>IN</sub> )   | ON – (OFF)              |

QUICK START PROCEDURE

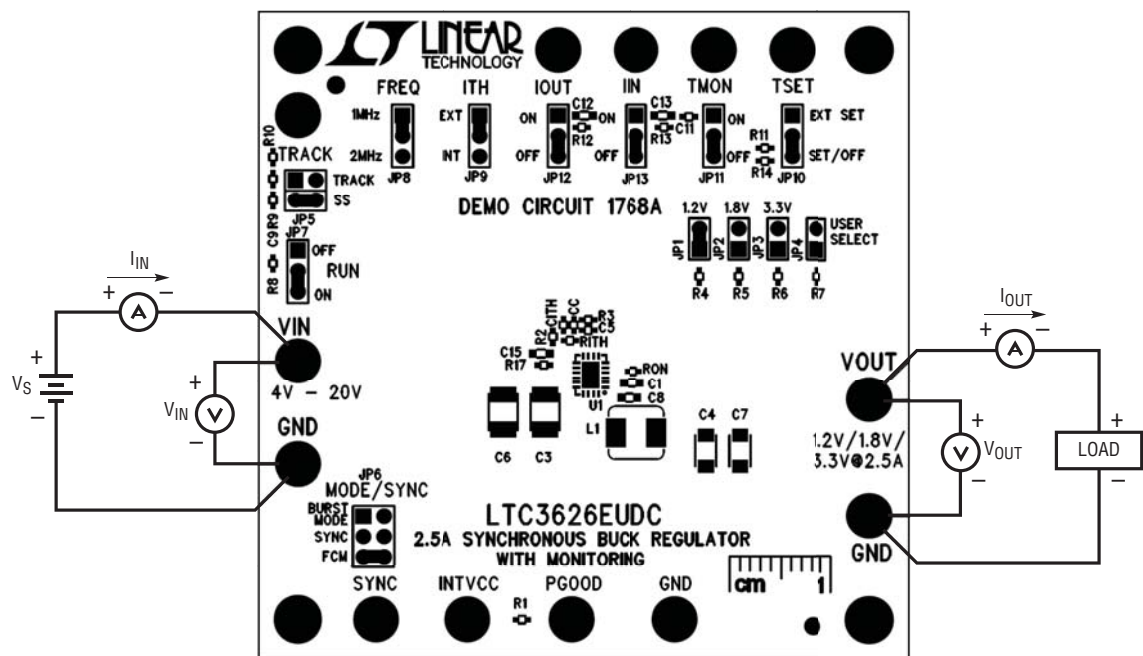


Figure 1. Proper Equipment Measurement Set-Up

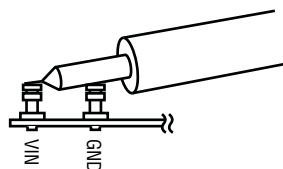
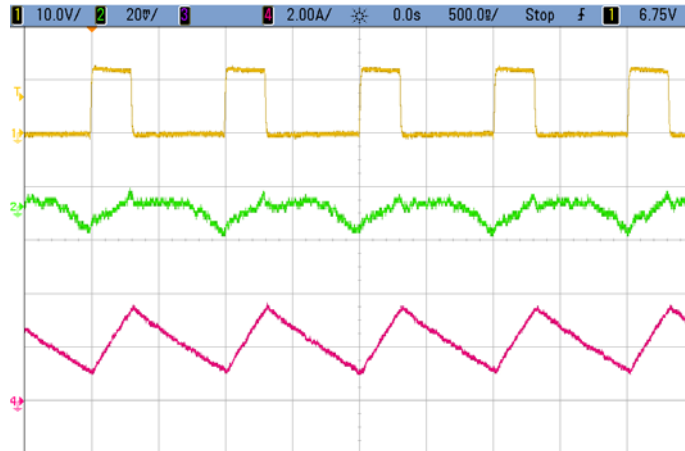


Figure 2. Measuring Input or Output Ripple

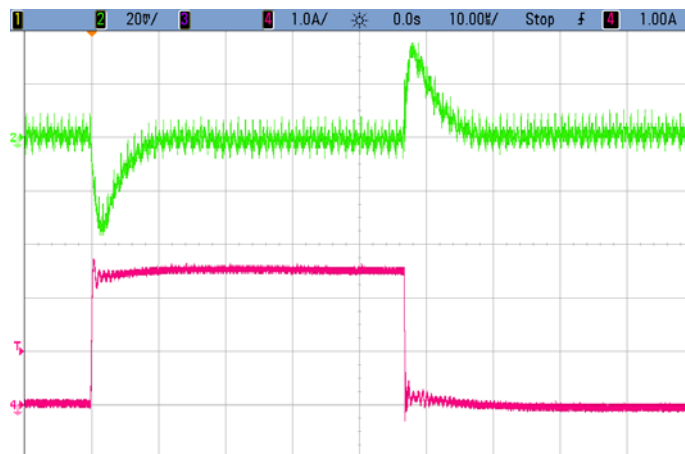
## QUICK START PROCEDURE

### Normal Switching Frequency and Output Ripple Voltage Waveforms



**Figure 3. Switch Node Voltage, Output Ripple Voltage & Inductor Ripple Current Waveforms**  
 $V_{IN} = 12V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2.5A$ ,  $f_{SW} = 1MHz$  Trace 1: Switch Voltage (10V/DIV)  
 Trace 2: Output Ripple Voltage (20mV/DIV AC) Trace 4: Inductor Ripple Current (2A/DIV)

### Load Step Response Waveforms



**Figure 4. Load Step Response**  $V_{IN} = 12V$ .  $V_{OUT} = 1.2V$ , 2.5A Load Step (0A-2.5A)  
 Forced Continuous Mode,  $f_{SW} = 1MHz$ . Trace 2: Output Voltage (20mV/DIV AC)  
 Trace 4: Output Current (1A/DIV)

## QUICK START PROCEDURE

Load Step Response Waveforms

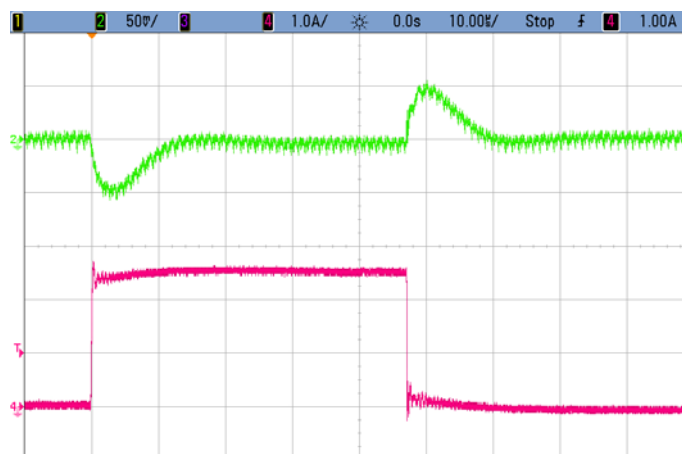


Figure 5. Load Step Response  $V_{IN} = 12V$ ,  $V_{OUT} = 1.8V$ , 2.5A Load Step (0A-2.5A)  
Forced Continuous Mode  $f_{SW} = 1MHz$  Trace 2: Output Voltage (50mV/DIV AC)  
Trace 4: Output Current (1A/DIV)

Load Step Response Waveforms

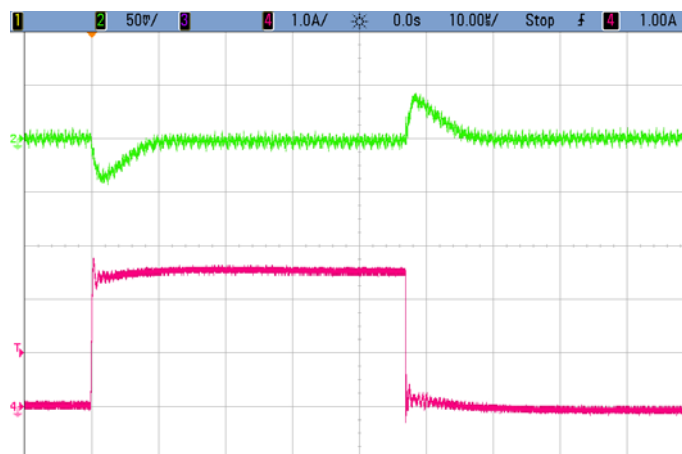


Figure 6. Load Step Response  $V_{IN} = 12V$ ,  $V_{OUT} = 3.3V$ , 2.5A Load Step (0A-2.5A)  
Forced Continuous Mode  $f_{SW} = 1MHz$  Trace 2: Output Voltage (50mV/DIV AC)  
Trace 4: Output Current (1A/DIV)

## QUICK START PROCEDURE



Figure 7. Input and Output Current Monitoring  $V_{IN} = 12V$ ,  $I_{IN} = 620mA$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2A$ ,  $f_{SW} = 1MHz$   
 Trace 1:  $I_{OUTMON}$  Voltage (0.5V/DIV) Trace 2:  $I_{INMON}$  Voltage (0.1V/DIV) Trace 3:  $I_{OUT}$  Current (2A/DIV)  
 Trace 4:  $I_{IN}$  Current (500mA/DIV)

With a Current Sense Resistor of 4.02k Connected to Both The Input and Output Current Monitors, Their Voltages Equate to:

$$V_{IOUTMON} = 2A / 16000 \times 4.02k = 0.503V$$

$$V_{INMON} = 620mA / 16000 \times 4.02k = 0.156V$$

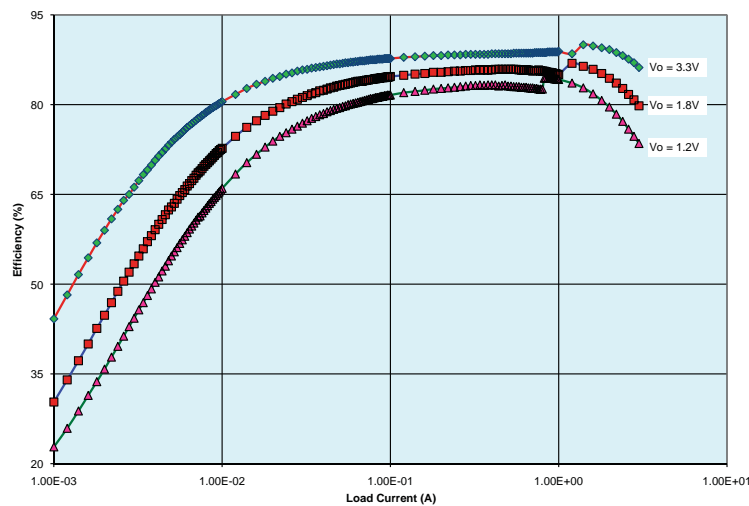


Figure 8. Efficiency Graph  $V_{IN} = 12V$ , Burst Mode,  
 $f_{SW} = 1MHz$  L:1  $\mu H$  Vishay IHL-2020BZ-ER-1R0-M01

# DEMO MANUAL DC1768A

## PARTS LIST

| ITEM  | QTY | REFERENCE            | PART DESCRIPTION                   | MANUFACTURER/PART NUMBER        |
|---|-----|----------------------|------------------------------------|---------------------------------|
| <b>Required Circuit Components</b>              |     |                      |                                    |                                 |
| 1   | 1   | C <sub>ITH</sub>     | Cap., NP0, 220pF, 25V, 10%, 0402   | AVX, 04023A221KAT2A             |
| 2   | 1   | C1                   | Cap., X5R, 2.2μF, 16V, 20%, 0603   | TDK, C1608X5R1C225M             |
| 3   | 2   | C3, C6               | Cap., X7R, 22μF, 25V, 20%, 1210    | MURATA, GRM32ER71E226M          |
| 4   | 1   | C4                   | Cap., X5R, 47μF, 6.3V, 20%, 1206   | Taiyo Yuden, JMK316BJ476ML-T    |
| 5   | 1   | C5                   | Cap., NP0, 22pF, 50V, 10% 0402     | AVX, 04025A220KAT               |
| 6   | 1   | C8                   | Cap., X7R, 0.1μF, 25V, 10% 0603    | TDK, C1608X7R1E104K             |
| 7   | 1   | C11                  | Cap., X5R, 1μF, 6.3V, 10% 0402     | AVX, 04026D105KAT2A             |
| 8   | 1   | L1                   | Inductor, 1.0μH IHLP-2020BZ-01     | Vishay IHLP-2020BZER1R0M01      |
| 9   | 1   | R1TH                 | Res., Chip, 13k, 0.06W, 5% 0402    | VISHAY, CRCW040213K0JNED        |
| 10  | 2   | R3, R4               | Res., Chip, 115k, 0.06W, 1% 0402   | VISHAY, CRCW0402115KFKE         |
| 11  | 1   | U1                   | IC. LTC3626EUDC, 3 × 4mm, 20 QFN   | LINEAR TECH., LTC3626EUDC#PBF   |
| <b>Additional Demo Board Circuit Components</b> |     |                      |                                    |                                 |
| 12  | 0   | CC(OPT)              | Cap., 0402                         |                                 |
| 13  | 1   | C2                   | Cap., Tant. 3.3μF, 35V, 20%, 6032  | AVX, TAJW335M035R               |
| 14  | 0   | C7, C10(OPT)         | Cap., 1206                         |                                 |
| 15  | 1   | C9                   | Cap., X7R, 2200pF, 25V, 20%, 0402  | AVX, 04023C225MAT               |
| 16  | 2   | C12, C13             | Cap., X5R, 1μF, 25V, 10%, 0603     | TDK, C1608X5R1E105K             |
| 17  | 0   | C14(OPT)             | Cap., 1812                         |                                 |
| 18  | 1   | C15                  | Cap., X5R, 0.33μF, 25V, 20%, 0603  | AVX, 06033D334MAT               |
| 19  | 0   | D1(OPT)              | Schottky Diode, SOD-323            |                                 |
| 20  | 2   | R10, R <sub>ON</sub> | Res., Chip, 0Ω, 0.06W, 0402        | VISHAY, CRCW04020000Z0ED        |
| 21  | 1   | R1                   | Res., Chip, 100k, 0.06W, 5%, 0402  | VISHAY, CRCW0402100KFKE         |
| 22  | 1   | R2                   | Res., Chip, 324k, 0.06W, 1%, 0402  | NIC, NRC04F3243TRF              |
| 23  | 1   | R5                   | Res., Chip, 57.6k, 0.06W, 1%, 0402 | VISHAY, CRCW040257K6FKE         |
| 24  | 1   | R6                   | Res., Chip, 25.5k, 0.06W, 1%, 0402 | VISHAY, CRCW040225K5FKE         |
| 25  | 0   | R7, R9, R14(OPT)     | Res., 0402                         |                                 |
| 26  | 2   | R8, R11              | Res., Chip, 1M, 0.06W, 5%, 0402    | VISHAY, CRCW04021M00JNED        |
| 27  | 2   | R12, R13             | Res., Chip, 4.02k, 0.06W, 1%, 0402 | VISHAY, CRCW04024K02FKE         |
| 28  | 1   | R17                  | Res., Chip, 10Ω, 0.06W, 5%, 0402   | VISHAY, CRCW040210R0JNED        |
| <b>Hardware: For Demo Board Only</b>            |     |                      |                                    |                                 |
| 29  | 13  | E1-E13               | Turret, Testpoint                  | Mill Max2501-2-00-80-00-00-07-0 |
| 30  | 4   | JP1, JP2, JP3, JP4   | 2 PIN 0.079 SINGLE ROW HEADER      | SAMTEC, TMM102-02-L-S           |
| 31  | 1   | JP5                  | 2X2, 0.079 DOUBLE ROW HEADER       | SAMTEC, TMM102-02-L-D           |
| 32  | 1   | JP6                  | 2X3, 0.079 DOUBLE ROW HEADER       | SAMTEC, TMM103-02-L-D           |
| 33  | 7   | JP7-JP13             | 3 PIN 0.079 SINGLE ROW HEADER      | SAMTEC, TMM103-02-L-S           |
| 34  | 10  | XJP1, XJP5-XJPP13    | SHUNT, .079" CENTER                | SAMTEC, 2SN-BK-G                |
| 35  | 4   | MH1-MH4              | STAND-OFF, NYLON 0.25"             | KEystone, 8831(SNAP ON)         |





# DEMO MANUAL DC1768A

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