

# LTC3890-2

## 60V, Low $I_Q$ Multiphase Synchronous Step-Down Converter

### DESCRIPTION

Demonstration circuit 2236A-A is a high output voltage, high efficiency synchronous PolyPhase<sup>®</sup> buck converter featuring the [LTC<sup>®</sup>3890EUH-2](#). The DC2236A-A has a wide input voltage range of 16V up to 60V, and is capable of delivering up to 25A of output current. The output voltage is set to 12V, however, the output voltage can go as high as 24V, with certain modifications. The DC2236A-A supports three operation modes: Fixed frequency modulation, pulse-skipping and Burst Mode<sup>®</sup> operation. Fixed frequency mode of operation maximizes the output current, reduces output voltage ripple, and yields a low noise switching spectrum. Burst Mode employs a variable frequency switching algorithm that minimizes the no-load input quiescent current and improves efficiency at light loads.

The DC2236A-A consumes less than 50 $\mu$ A of quiescent current during shutdown and less than 1mA under a no

load condition with the output in regulation in Burst Mode operation. The DC2236A-A has a standard operating frequency of 150kHz, but can be adjusted to frequencies as high as 900kHz. The DC2236A is a dual phase single output step-down converter; however it is designed to be easily transformed to a 4- or 6- phase system by combining two or three DC2236A-A boards. The LTC3890EUH-2 data sheet gives a complete description of these parts, operation and application information and must be read in conjunction with this quick start guide for demonstration circuit 2236A-A. Table 1 summarizes the differences between the parts in the LTC3890 family.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2236A-A>**

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### PERFORMANCE SUMMARY

Specifications are at  $T_A = 25^\circ\text{C}$

| PARAMETER                            | CONDITIONS                                                                                                                            | VALUE                |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Minimum Input Voltage                |                                                                                                                                       | 16V                  |
| Maximum Input Voltage                |                                                                                                                                       | 60V                  |
| Output Voltage $V_{OUT}$ Regulation  | $V_{IN} = 16\text{V to } 55\text{V}$                                                                                                  | $12\text{V} \pm 2\%$ |
| Maximum Continuous Output Current    |                                                                                                                                       | 25A                  |
| Preset Operating Frequency           | $R7 = 30.1\text{k}\Omega$                                                                                                             | 150kHz               |
| External Clock Sync. Frequency Range |                                                                                                                                       | 75kHz to 850kHz      |
| Efficiency                           | $V_{IN} = 36\text{V}$ , $V_{OUT} = 12\text{V}$ , $I_{OUT} = 12\text{A}$ , See Figure 3 Efficiency Curves for Complete Operating Range | 97%                  |
| Typical Output Ripple $V_{OUT}$      | $V_{IN} = 36\text{V}$ , $I_{OUT} = 12\text{A}$ (20MHz BW)                                                                             | <35mV <sub>p-p</sub> |
| Quiescent Current at Shutdown        | $V_{IN} = 16\text{V to } 55\text{V}$                                                                                                  | <50 $\mu$ A          |
| Input Current at No Load             | $V_{IN} = 16\text{V to } 55\text{V}$                                                                                                  | <1mA                 |

## QUICK START PROCEDURE

Demonstration circuit 2236A-A is easy to set up to evaluate the performance of the LTC3890-2. For proper measurement equipment configuration, set up the circuit according to the diagram in Figure 1. Before proceeding to test, insert shunt into JP1 (RUN) OFF position, which connects the RUN pin to ground (GND), and thus, shuts down the circuit.

NOTE: 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 technique.

1. With the DC2236A-A set up according to the proper measurement and equipment in Figure 1, apply 20V at  $V_{IN}$ . Measure  $V_{OUT}$ ; it should read 0V. If desired, one can measure the shutdown supply current at this point. The supply current will be approximately 50 $\mu$ A, or less, in shutdown.

2. Turn on the circuit by inserting the shunt in header JP1 (RUN) into the ON position. The output voltage should be regulating. Measure  $V_{OUT}$  – it should measure 12V  $\pm$  2% (**Do not apply more than the rated maximum voltage of 60V to the board or the part may be damaged**).
3. Vary the converter load, which should not exceed 25A. Note: all four input and output terminals  $V_{IN}$ ,  $V_{OUT}$  and two GND equipped with two banana connectors, two-wires can be used for each terminal to reduce copper losses and heat dissipation in the interconnection lines.
4. Vary the input voltage from 16V to 55V, the  $V_{OUT}$  – it should measure 12V  $\pm$  2%
5. Set output current to zero and move jumper JP2 (MODE) into BURST MODE position and measure  $V_{OUT}$  – it should register 12V  $\pm$  2%.
6. Set output current to zero and move jumper JP2 (MODE) into PLS SKIP position and measure  $V_{OUT}$  – it should register 12V  $\pm$  2%

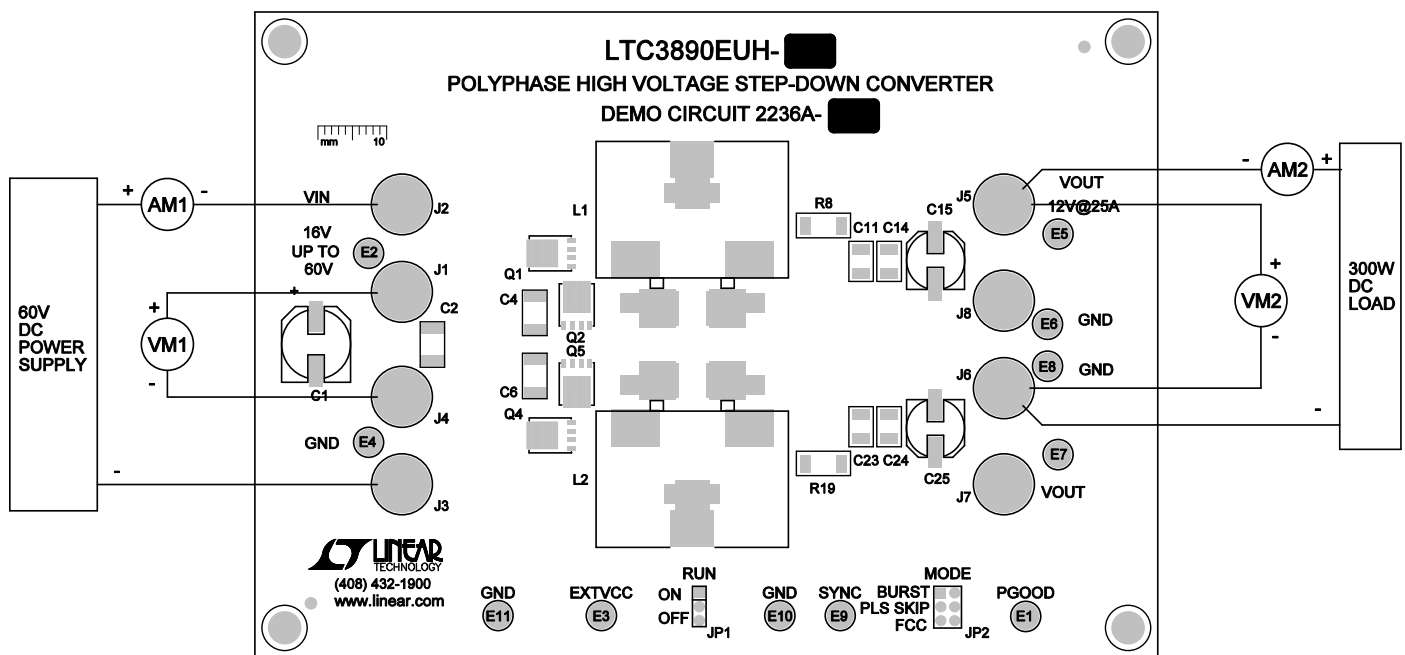


Figure 1. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

**Table 1. Summary of the Differences Between the Parts in the LTC3890 Family**

|                                                                               | <b>LTC3890</b>                                                              | <b>LTC3890-1</b>                                                            | <b>LTC3890-2</b>                                                                                                                                  | <b>LTC3890-3</b>                                                                                                                                  |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| I <sub>LIM</sub> Pin for Adjustable Current Sense Voltage?                    | Yes                                                                         | No                                                                          | Yes                                                                                                                                               | No                                                                                                                                                |
| CLKOUT and PHASMD Pins for PolyPhase® Operation?                              | Yes                                                                         | No                                                                          | Yes                                                                                                                                               | No                                                                                                                                                |
| Independent PGOOD Pins for Each Channel                                       | Yes; PGOOD1 and PGOOD2                                                      | No; PGOOD1 Only                                                             | Yes; PGOOD1 and PGOOD2                                                                                                                            | No; PGOOD1 Only                                                                                                                                   |
| Overvoltage Protection Bottom Gate “Crowbar?”                                 | Yes                                                                         | Yes                                                                         | No; BG Not Forced On                                                                                                                              | No; BG Not Forced On                                                                                                                              |
| Current Foldback During Overcurrent Events                                    | Yes                                                                         | Yes                                                                         | No                                                                                                                                                | No                                                                                                                                                |
| Light Load Operation When Synchronized to External Clock Using PLLIN/MODE Pin | Forced Continuous                                                           | Forced Continuous                                                           | Pulse-Skipping                                                                                                                                    | Pulse-Skipping                                                                                                                                    |
| SENSE Pins Common Mode Range                                                  | Operation with SENSE Common Mode < 0.5V<br>Requires V <sub>FB</sub> < 0.65V | Operation with SENSE Common Mode < 0.5V<br>Requires V <sub>FB</sub> < 0.65V | Not Dependent on V <sub>FB</sub> Voltage. Makes It Easy to Make a Non-synchronous Boost or SEPIC Converter with Ground-Referenced Current Sensing | Not Dependent on V <sub>FB</sub> Voltage. Makes It Easy to Make a Non-synchronous Boost or SEPIC Converter with Ground-Referenced Current Sensing |

QUICK START PROCEDURE

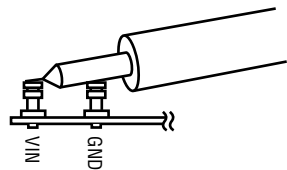


Figure 2. Measuring Input or Output Ripple

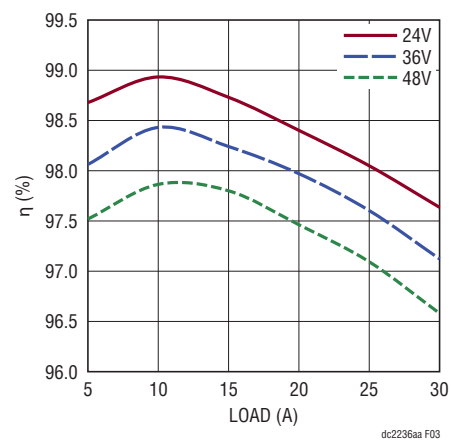


Figure 3. Efficiency vs Load

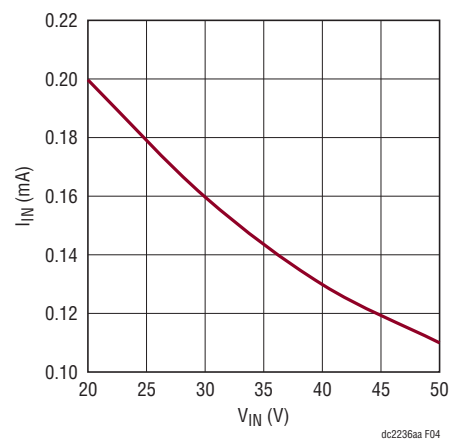


Figure 4. Input Current at No Load vs Input Voltage (Burst Mode)

## QUICK START PROCEDURE

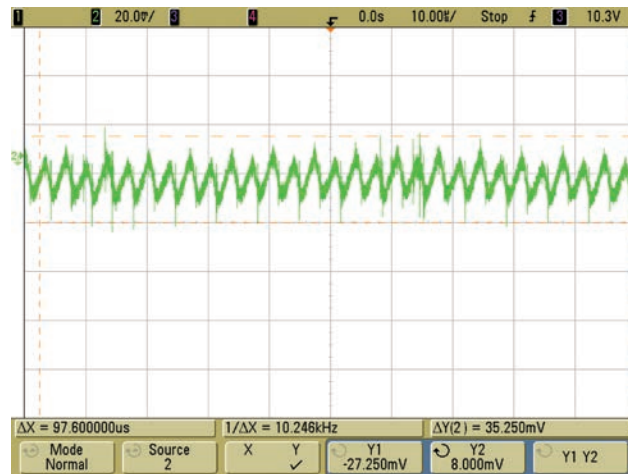


Figure 5. Output Noise,  $V_{IN}$  36V,  $I_O$  12A

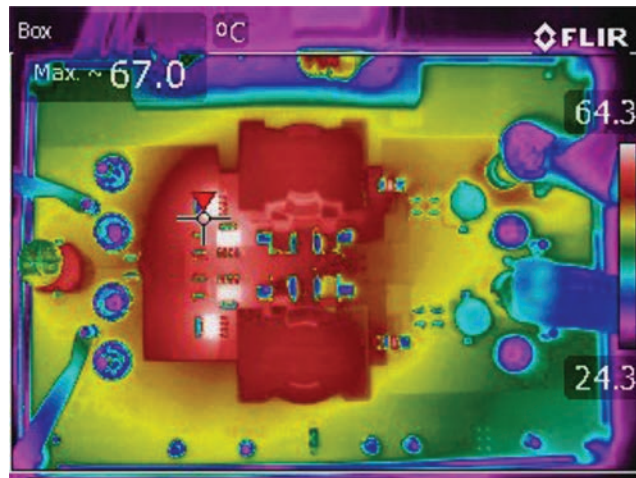


Figure 6. Thermal Map,  $V_{IN}$  48V,  $V_O$  12V,  $I_O$  25A, No Air Flow

# DEMO MANUAL DC2236A-A

## PARTS LIST

| ITEM                                            | QTY | REFERENCE                       | PART DESCRIPTION                     | MANUFACTURER/PART NUMBER          |
|-------------------------------------------------|-----|---------------------------------|--------------------------------------|-----------------------------------|
| <b>Required Circuit Components</b>              |     |                                 |                                      |                                   |
| 1                                               | 2   | C1, C29                         | CAP., ALUM., 56μF, 63V, 20%          | SUN ELECT., 63HVVH56M             |
| 2                                               | 6   | C2, C3, C4, C5, C6, C7          | CAP., X7R, 2.2μF, 100V, 10%, 1812    | TDK, C4532X7R2A225K               |
| 3                                               | 2   | C8, C26                         | CAP., NPO, 2.2pF, 50V, ±0.25pF, 0603 | AVX, 06035A2R2CAT                 |
| 4                                               | 1   | C9                              | CAP., X7S, 1μF, 100V, 10%, 0805      | TDK, C2012X7S2A105K330            |
| 5                                               | 4   | C11, C14, C23, C24              | CAP., X5R, 10μF, 50V, 1210, 20%      | TAIYO YUDEN, UMK325BJ106MM-T      |
| 6                                               | 3   | C12, C16, C21                   | CAP., X7R, 0.1μF, 50V, 10%, 0603     | TDK, C1608X7R1H104K               |
| 7                                               | 2   | C15, C25                        | CAP., SANYO, 150μF, 16V, 20%         | SANYO, 16TSVPC150                 |
| 8                                               | 1   | C17                             | CAP., X7R, 4.7nF, 100V, 10%, 0603    | AVX, 06031C472KAT                 |
| 9                                               | 2   | C18, C19                        | CAP., NPO, 47pF, 25V, 10%, 0603      | AVX, 06033A470KAT2A               |
| 10                                              | 2   | C20                             | CAP., X7R, 4.7μF, 10V, 10%, 0603     | TAIYO YUDEN, LMK107BJ475KA-T      |
| 11                                              | 1   | C22                             | CAP., NPO, 10pF, 25V, 10%, 0603      | AVX, 06033A100KAT2A               |
| 12                                              | 1   | C27                             | CAP., X5R, 1μF, 25V, 10%, 0603       | AVX, 06033D105KAT2A               |
| 13                                              | 2   | D1, D2                          | DIODE, SCHOTTKY, DFLS1100, PDI-123   | DIODES, INC., DFLS1100            |
| 14                                              | 2   | L1, L2                          | IND., 10μH, SMD                      | COILCRAFT SER2915L-103KL          |
| 15                                              | 2   | Q1, Q4                          | RENESAS, N CH POWER MOS FET          | RENESAS, RJK0651DPB               |
| 16                                              | 2   | Q2, Q5                          | RENESAS, N CH POWER MOS FET          | RENESAS, RJK0653DPB               |
| 17                                              | 1   | R1                              | RES., 2.2Ω, 1%, 1/10W, 0603          | VISHAY, CRCW06032R20FNEA          |
| 18                                              | 2   | R4, R22                         | RES., 100Ω, 1%, 1/10W, 0603          | VISHAY, CRCW0603100RFKEA          |
| 19                                              | 6   | R2, R10, R14, R15, R24, R27     | RES., 0Ω, 1/10W, 0603                | VISHAY, CRCW06030000Z0EA          |
| 20                                              | 1   | R6                              | RES., 1M, 5%, 0805                   | VISHAY, CRCW08051M00JNED          |
| 21                                              | 1   | R7                              | RES., 30.1k, 1%, 1/10W, 0603         | VISHAY, CRCW060330K1FKEA          |
| 22                                              | 2   | R8, R19                         | RES., 0.003Ω, 1%, 1/2W, 2010         | VISHAY, WSL20103L000FEA           |
| 23                                              | 1   | R9                              | RES., 57.6k, 1%, 1/10W, 0603         | VISHAY, CRCW060357K6FKEA          |
| 24                                              | 2   | R12, R18                        | RES., 0Ω, 1/10W, 0805                | VISHAY, CRCW08050000Z0EA          |
| 25                                              | 1   | R13                             | RES., 9.76k, 1%, 1/10W, 0603         | VISHAY, CRCW060315K0FKEA          |
| 26                                              | 1   | R16                             | RES., 499k, 1%, 1/10W, 0603          | VISHAY, CRCW0603499KFKEA          |
| 27                                              | 1   | R20                             | RES., 35.7k, 1%, 1/10W, 0603         | VISHAY, CRCW060335K7FKEA          |
| 28                                              | 2   | R21, R29                        | RES., 100k, 1%, 1/10W, 0603          | VISHAY, CRCW0603100KFKEA          |
| 29                                              | 1   | R28                             | RES., 1k, 1%, 1/10W, 0603            | VISHAY, CRCW06031K00FKEA          |
| 30                                              | 1   | U1                              | I.C., LTC3890EUH-2, QFN-32-UH        | LINEAR TECH. LTC3890EUH-2         |
| <b>Additional Demo Board Circuit Components</b> |     |                                 |                                      |                                   |
| 1                                               | 0   | R3, R5, C10, C13, R25, R26, C28 | OPT                                  | 0603 PACKAGE                      |
| 2                                               | 0   | Q3, Q6, Q7, Q8                  | OPT                                  | LFPACK PACKAGE                    |
| <b>Hardware: For Demo Board Only</b>            |     |                                 |                                      |                                   |
| 1                                               | 11  | E1-E11                          | TESTPOINT, TURRET, 0.094"            | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2                                               | 2   | JP1, JP2                        | JMP, 3PIN 1 ROW, 0.079"              | SAMTEC, TMM-103-02-L-S            |
| 3                                               | 2   | XJP1, XJP2                      | SHUNT, 0.079" CENTER                 | SAMTEC, 2SN-BK-G                  |
| 4                                               | 7   | J1-J8                           | CONNECTOR, BANANA JACK               | KEYSTONE, 575-4                   |
| 5                                               | 4   | MTGS AT 4 CORNERS               | STANDOFF, NYLON 0.5 1/2"             | KEYSTONE, 8833(SNAP-ON)           |



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