# LTC3605A 20V, 5A Monolithic Synchronous Step-Down Regulator

## DESCRIPTION

Demonstration circuit 1897 is a step-down converter, using the LTC®3605A monolithic synchronous buck regulator. The DC1897B has a maximum input voltage of 20V, and is capable of delivering up to 5A of output current at a minimum input voltage of 4V. The output voltage of the DC1897B can be set as low as 0.6V, the reference voltage of the LTC3605A. At low load currents, the DC1897B operates in discontinuous mode, and during shutdown, it consumes 11µA of quiescent current typically. The DC1897B can achieve efficiency over 90%. The LTC3605A has phase-lock-loop circuits, allowing high current multiphase operation of several DC1897Bs in parallel. The DC1897B can also track another voltage with the LTC3605A track function. Because of the high switching frequency of the LTC3605A, which is programmable up to 4MHz, the DC1897B uses low profile surface mount components. All these features make the DC1897B an ideal circuit for use in industrial applications and distributed power systems

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



## PERFORMANCE SUMMARY

**Table 1. Performance Summary**

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Input Voltage Range | | 4V to 20V |
| Output Voltage Range | | 0.6V to 5V |
| Run/Shutdown | | GND = Shutdown |
| | | $V_{IN}$ = Run |
| Output Voltage Regulation | $V_{IN}$ = 4V to 20V, $I_{OUT}$ = 0A to 5A<br>$V_{IN}$ = 4.7V to 20V, $I_{OUT}$ = 0A to 5A<br>$V_{IN}$ = 6.4V to 20V, $I_{OUT}$ = 0A to 5A | 2.5V ±2% Typical (2.45V to 2.55V)<br>3.3V ±2% Typical (3.234V to 3.366V)<br>5V ±2% Typical (4.9V to 5.1V) |
| Typical Output Ripple Voltage | $V_{IN}$ = 12V, $V_{OUT}$ = 2.5V<br>$I_{OUT}$ = 5A (20MHz BW) | <20mV$_{P-P}$ |
| Discontinuous Mode | $V_{IN}$ = 12V, $V_{OUT}$ = 2.5V<br>$V_{IN}$ = 12V, $V_{OUT}$ = 3.3V<br>$V_{IN}$ = 12V, $V_{OUT}$ = 5V | $I_{OUT}$ < 1.25A<br>$I_{OUT}$ < 1.45A<br>$I_{OUT}$ < 1.65A |
| Phase | Phase = $INTV_{CC}$<br>Phase = GND<br>Phase = Floating | 180° Out-of-Phase: 2 Phase<br>120° Out-of-Phase: 3 Phase<br>90° Out-of-Phase: 4 Phase |
| Nominal Switching Frequency | $R_T$ = 162k | 1MHz ±20% |

**Table 2. Jumper Description**

| JUMPER | FUNCTION | RANGE/SETTING (DEFAULT) |
|---|---|---|
| JP1 | Output Voltage Setting | 2.5V |
| JP5 | Phase Mode (PHMODE): 180 Degrees Out-of-Phase (DOP) – 2 Phase, 120 DOP – 3 Phase, or 90 DOP – 4 Phase | (2 PHASE) – 3 PHASE – 4 PHASE |
| JP6 | Mode: Forced Continuous Mode (FCM) or Discontinuous Mode (DCM) | (FCM) – DCM |
| JP7 | Run | (ON) – OFF |

## QUICK START PROCEDURE

Demonstration Circuit 1897 is easy to set up to evaluate the performance of the LTC3605A. 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 these positions: the 2.5V output voltage header JP1, the 180° out-of-phase (2-PHASE) position of the phase mode (PHMODE) header JP5, the forced continuous mode (FCM) position of mode header JP6, and the on position of run header JP7.

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 VIN or VOUT and GND terminals. See Figure 2 for proper scope probe measurement technique.

With the DC1897B set up according to the proper measurement configuration and equipment in Figure 1, apply 6.3V at VIN (do not increase $V_{IN}$ over the rated maximum supply voltage of 20V, or the part may be damaged). Measure $V_{OUT}$; it should read 2.5V (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 2.5V ±2% (2.45V to 2.55V).

Vary the input voltage from 4V to 20V and adjust the load current from 0 to 5A. $V_{OUT}$ should regulate around 2.5V ±3% (2.425V to 2.575V). Measure the output ripple voltage—it should measure less than 30mV AC.

Observe the voltage waveform at the switch pins (the other side of the inductor from the output). Verify the switching frequency is between 800kHz and 1.2MHz (t = 1.25ns and 833ns), and that the switch node waveform is rectangular in shape.

Change the shunt position on the MODE header from FCM to DCM (discontinuous mode). Set the input voltage to 12V and the output current to any current less than 1A. Observe the discontinuous mode of operation at the switch node, and measure the output ripple voltage. It should measure less than 100mV AC.

Insert the JP7 shunt into the OFF position and move the shunt in the 2.5V output JP1 header into any of the two remaining output voltage option headers: 3.3V (JP2) or 5V (JP3). Just as in the 2.5V VOUT test, the output voltage should read VOUT ±1% tolerance under static line and load conditions and ±1% tolerance under dynamic line and load conditions (±2% total). Also, the circuit operation in discontinuous mode will be the same. When finished, turn off the circuit by inserting the shunt in header JP7 into the OFF position.

## QUICK START PROCEDURE

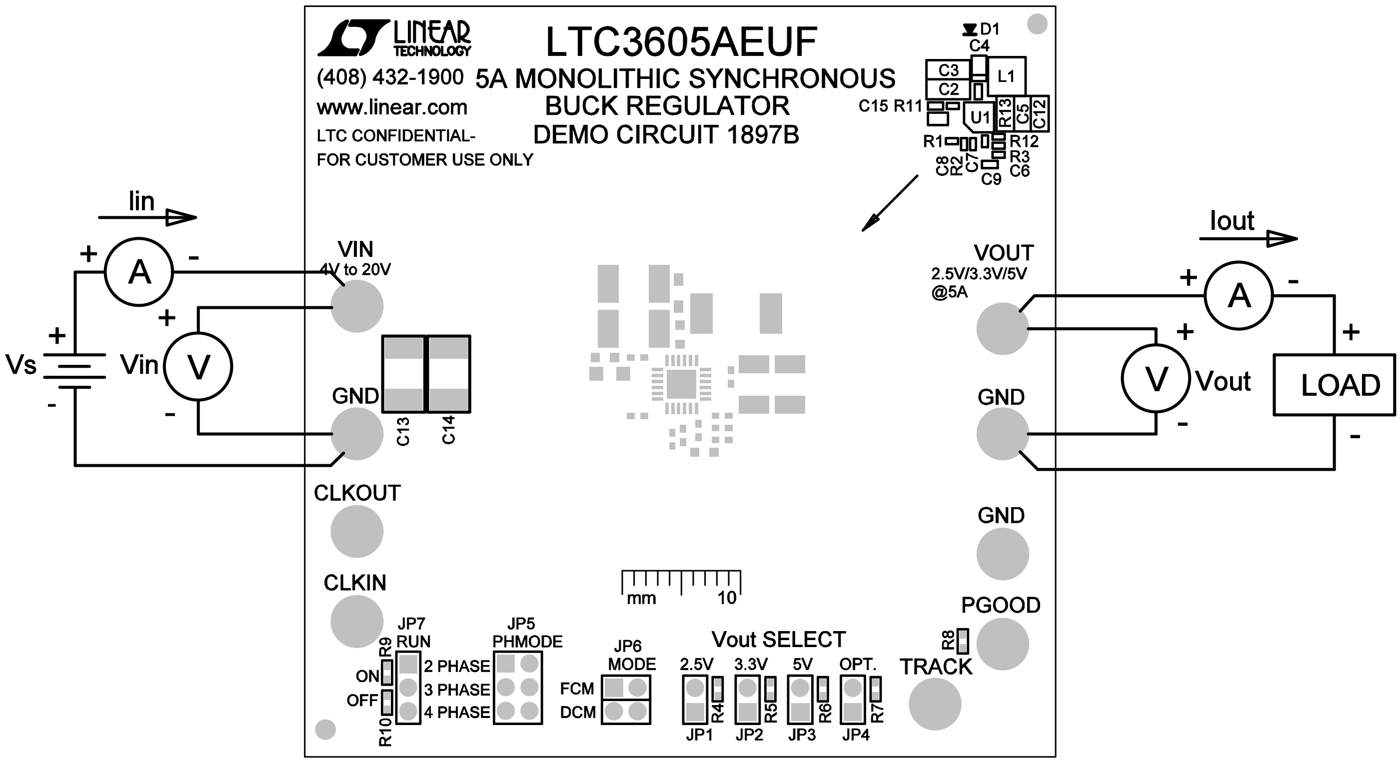



Figure 1. Proper Equipment Measurement Setup

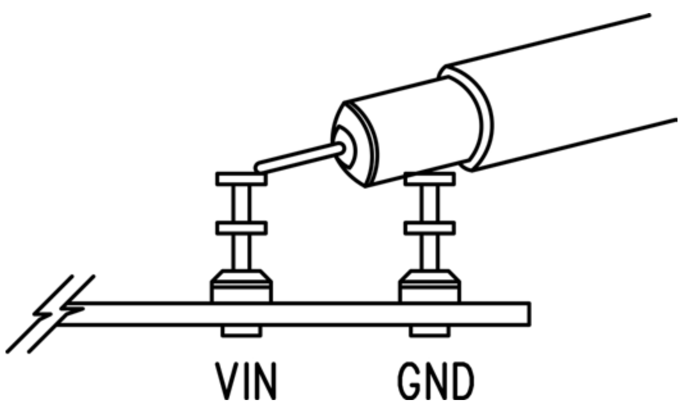



Figure 2. Measuring Input or Output Ripple

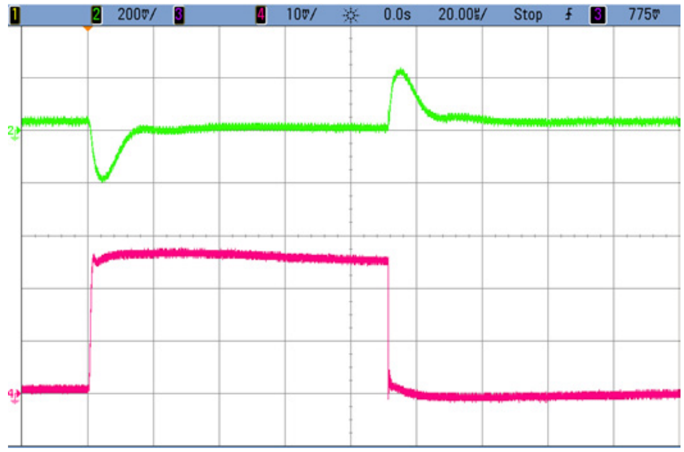
# QUICK START PROCEDURE

**Normal Switching Frequency and Output Ripple Voltage Waveforms**


$V_{IN}$ = 12V, $V_{OUT}$ = 5V, $I_{OUT}$ = 5A, $f_{SW}$ = 1MHz
Trace 1: Switch Voltage (5V/Div)
Trace 2: Output Ripple Voltage (20mV/Div AC)

Figure 3. Switch Node and Output Ripple Voltage Waveforms

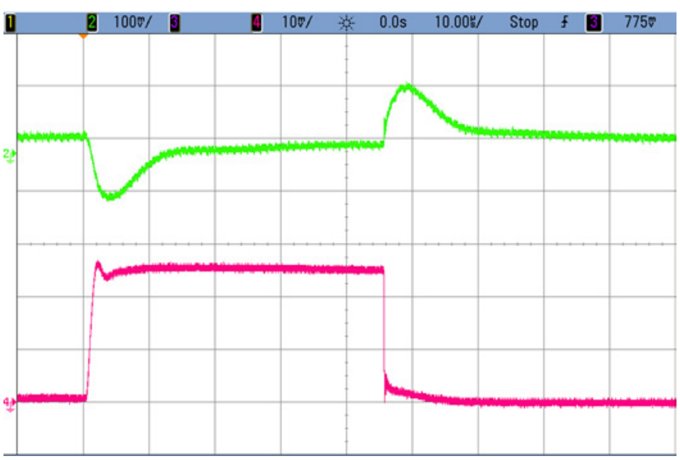
**Load Step Response Waveforms**




$V_{IN}$ = 12V, $V_{OUT}$ = 5V, 5A Load Step (0A to 5A)
Forced Continuous Mode, $f_{SW}$ = 1MHz
Trace 2: Output Voltage (200mV/Div AC)
Trace 4: Output Current (2A/Div)

Figure 4. Load Step Response

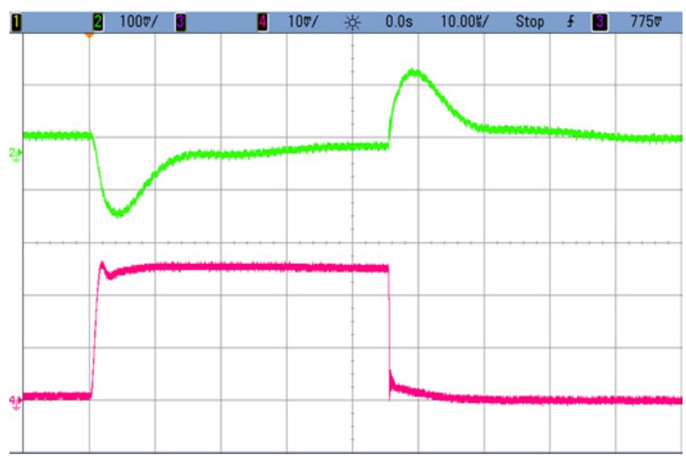
**Load Step Response Waveforms**




$V_{IN}$ = 12V, $V_{OUT}$ = 2.5V, 5A Load Step (0A to 5A)
Forced Continuous Mode, $f_{SW}$ = 1MHz
Trace 2: Output Voltage (100mV/Div AC)
Trace 4: Output Current (2A/Div)

Figure 5. Load Step Response

**Load Step Response Waveforms**

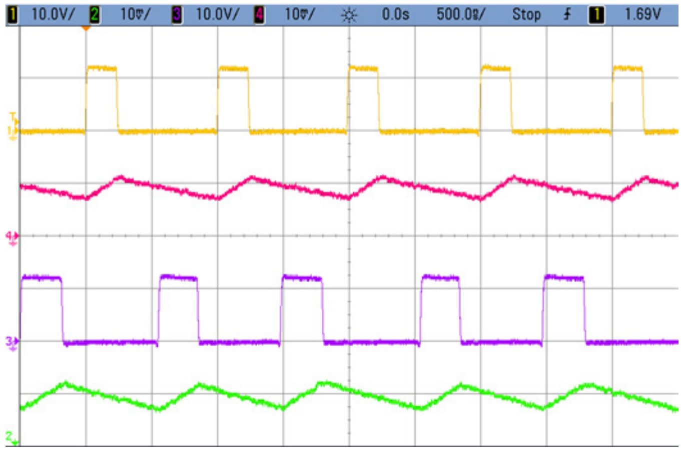



$V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, 5A Load Step (0A to 5A)
Forced Continuous Mode, $f_{SW}$ = 1MHz
Trace 2: Output Voltage (100mV/Div AC)
Trace 4: Output Current (2A/Div)

Figure 6. Load Step Response

## QUICK START PROCEDURE

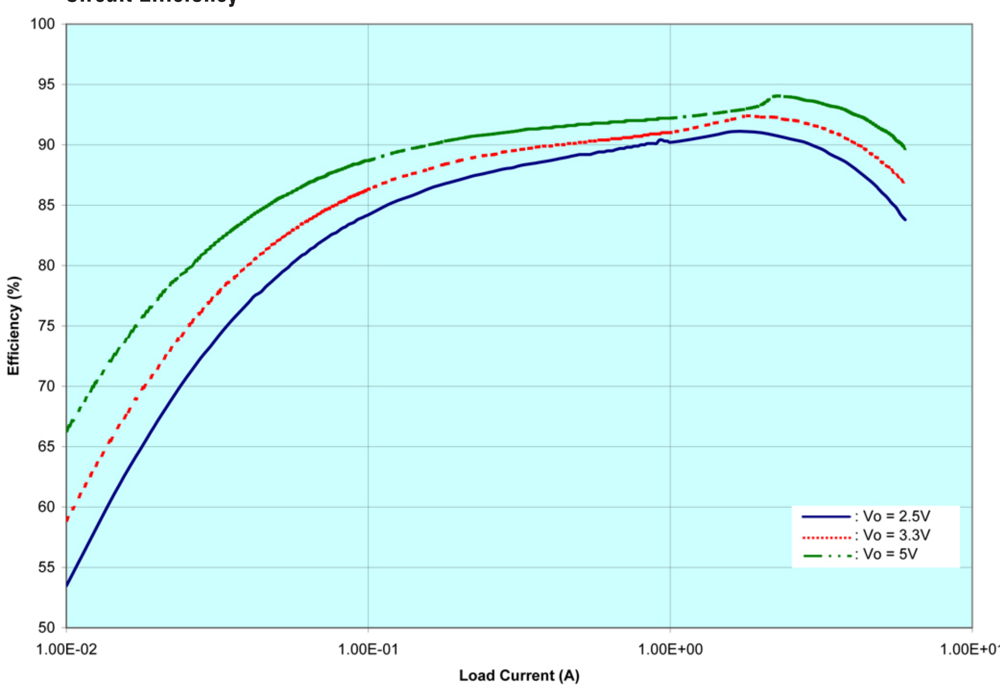
**2-Phase Dual Output Waveforms**




$V_{IN}$ = 12V, $V_{OUT1}$ = 2.5V, $I_{OUT1}$ = 5A, $V_{OUT2}$ = 3.3V, $I_{OUT2}$ = 5A,
$f_{SW}$ = 1MHz
Trace 1: $V_{OUT1}$ Switch Voltage (10V/Div)
Trace 4: L1 Ripple Current (5A/Div)
Trace 3: $V_{OUT2}$ Switch Voltage (10V/Div)
Trace 2: L2 Ripple Current (5A/Div)

**Figure 7. Switch Node Voltage and Inductor Ripple Current Waveforms of Two Circuits Operating 180° Out-of-Phase**

**Circuit Efficiency**



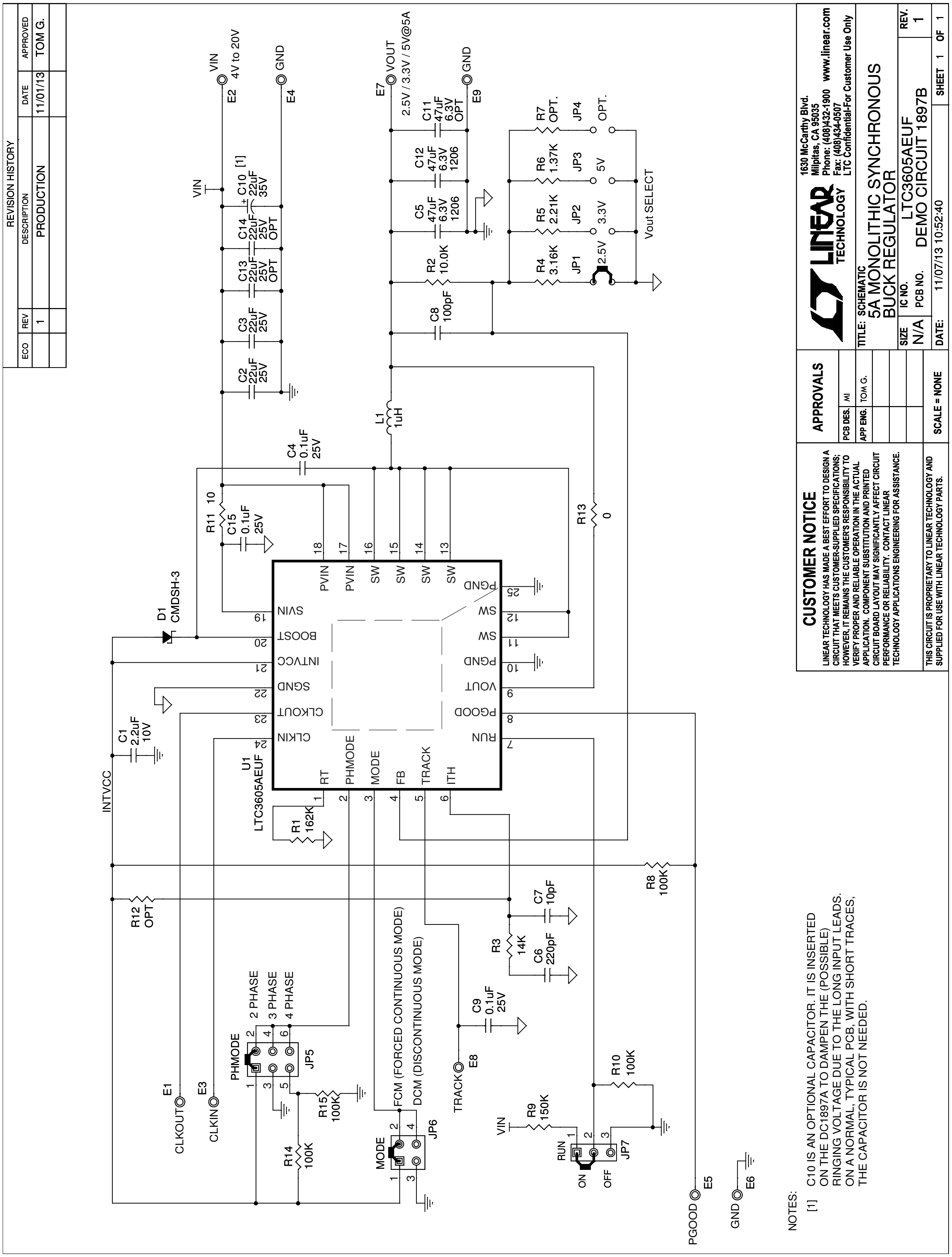

$V_{IN}$ = 12V
Discontinuous Mode, $f_{SW}$ = 1MHz

**Figure 8. Efficiency Graph**

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 1 | C1 | CAP, 0805 2.2µF 20% 10V X5R | AVX 0805ZD225MAT2A |
| 2 | 2 | C2, C3 | CAP, 1210 22µF 20% 25V X7R | MURATA GRM32ER61E226ME15L |
| 3 | 1 | C4 | CAP, 0603 0.1µF 20% 25V X7R | AVX 06033C104MAT2A |
| 4 | 2 | C5, C12 | CAP, 1206 47µF 20% 10V X5R | TAIYO YUDEN LMK316BJ476ML-T |
| 5 | 1 | C6 | CAP, 0402 220pF 20% 50V C0G | AVX 04025A221MAT2A |
| 6 | 1 | C7 | CAP, 0402 10pF 20% 50V C0G | AVX 04025A100MAT2A |
| 7 | 1 | C8 | CAP, 0402 100pF 20% 50V C0G | AVX 04025A101MAT2A |
| 8 | 1 | D1 | DIODE, CMDSH-3, SOD-323 | CENTRAL SEMI. CMDSH-3TR |
| 9 | 1 | L1 | IND 1.0µH | VISHAY IHLP2525CZER1R0M01 |
| 10 | 1 | R1 | RES, 0402 162k 1% 1/16W | VISHAY, CRCW0402162KFKED |
| 11 | 1 | R2 | RES, 0402 10k 1% 1/16W | VISHAY CRCW040210K0FKED |
| 12 | 1 | R3 | RES, 0402 14k 1% 1/16W | VISHAY CRCW040214K0FKED |
| 13 | 1 | R4 | RES, 0402 3.16k 1% 1/16W | VISHAY CRCW04023K16FKED |
| 14 | 1 | R13 | RES, 0402 0Ω JUMPER | VISHAY CRCW04020000Z0ED |
| 15 | 1 | U1 | IC, QFN24 | LINEAR TECHNOLOGY, LTC3605AEUF |
| **Additional Demo Board Circuit Components** | | | | |
| 1 | 2 | C9, C15 | CAP, 0603 0.1µF 20% 25V X7R | AVX 06033C104MAT2A |
| 2 | 1 | C10 | CAP, 7343 22µF 20% 35V TANT | AVX TPSY226M035R |
| 3 | 0 | C11 | CAP, 1206 OPTION | OPTION |
| 4 | 0 | C13, C14 | CAP, 1812 22µF 20% 25V X7R OPTION | TDK C4532X7R1E226M OPTION |
| 5 | 1 | R5 | RES, 0402 2.21k 1% 1/16W | VISHAY CRCW04022K21FKED |
| 6 | 1 | R6 | RES, 0402 1.37k 1% 1/16W | VISHAY CRCW04021K37FKED |
| 7 | 0 | R7, R12 | RES, 0402 OPTION | OPTION |
| 8 | 4 | R8, R10, R14, R15 | RES, 0402 100k 5% 1/16W | VISHAY CRCW0402100KJNED |
| 9 | 1 | R9 | RES, 0402 150k 5% 1/16W | VISHAY CRCW0402150KJNED |
| 11 | 1 | R11 | RES, 0402 10Ω 5% 1/16W | VISHAY CRCW040210R0JNED |
| **Hardware—For Demo Board Only** | | | | |
| 1 | 9 | E1-E9 | TURRET | MIIL-MAX 2501-2-00-80-00-00-07-0 |
| 2 | 4 | JP1, JP2, JP3, JP4 | HEADER, SINGLE ROW, 2-PIN, 2mm | SULLINS, NRPN021PAEN-RC |
| 3 | 1 | JP5 | HEADER, 3-PIN, DBL ROW 2mm | SULLINS, NRPN03PAEN-RC |
| 4 | 1 | JP6 | HEADER, 2mm DBL ROW (2X2) 4-PIN | SULLINS, NRPN022PAEN-RC |
| 5 | 1 | JP7 | HEADER, 2mm, 3-PIN | SULLINS, NRPN031PAEN-RC |
| 6 | 4 | JP1, JP5-JP7 | SHUNT, 2mm | SAMTEC 2SN-BK-G |

## SCHEMATIC DIAGRAM



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