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 DC1897A 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 DC1897A can be set as low as 0.6V, the reference voltage of the LTC3605A. At low load currents, the DC1897A operates in discontinuous mode, and during shutdown, it consumes 11µA of quiescent current typically. The DC1897A can achieve efficiency over 90%. The LTC3605A has phase-lock-loop circuits, allowing high current multiphase operation of several DC1897As in parallel. The DC1897A 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 DC1897A uses low profile surface mount components. All these features make the DC1897A 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 V_{IN} = 4.7V to 20V, I_{OUT} = 0A to 5A V_{IN} = 6.4V to 20V, I_{OUT} = 0A to 5A	2.5V ±2% Typical (2.45V to 2.55V) 3.3V ±2% Typical (3.234V to 3.366V) 5V ±2% Typical (4.9V to 5.1V)
Typical Output Ripple Voltage	V_{IN} = 12V, V_{OUT} = 2.5V I_{OUT} = 5A (20MHz BW)	<20mV_{P-P}
Discontinuous Mode	V_{IN} = 12V, V_{OUT} = 2.5V V_{IN} = 12V, V_{OUT} = 3.3V V_{IN} = 12V, V_{OUT} = 5V	I_{OUT} < 1.25A I_{OUT} < 1.45A I_{OUT} < 1.65A
Phase	Phase = $INTV_{CC}$ Phase = GND Phase = Floating	180° Out-of-Phase: 2 Phase 120° Out-of-Phase: 3 Phase 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 the correct locations: 2.5V position of the output voltage header JP1, into the 4-phase (90 degrees out-of-phase) position of PHMODE header JP5, into the DCM (discontinuous mode) position of MODE header JP6, and into 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 DC1897 set up according to the proper measurement configuration and equipment in Figure 1, apply 6.3V at VIN (do not increase VIN over the rated maximum supply voltage of 20V, or the part may be damaged). Measure VOUT; 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 VOUT—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. VOUT should regulate around 2.5V ±3% (2.425V to 2.575V). Measure the output ripple voltage—it should measure less than 20mV AC.

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 AC.

Change the shunt position on the MODE header from DCM 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 = 1.17µs and 833µs), and that the switch node waveform is rectangular in shape.

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

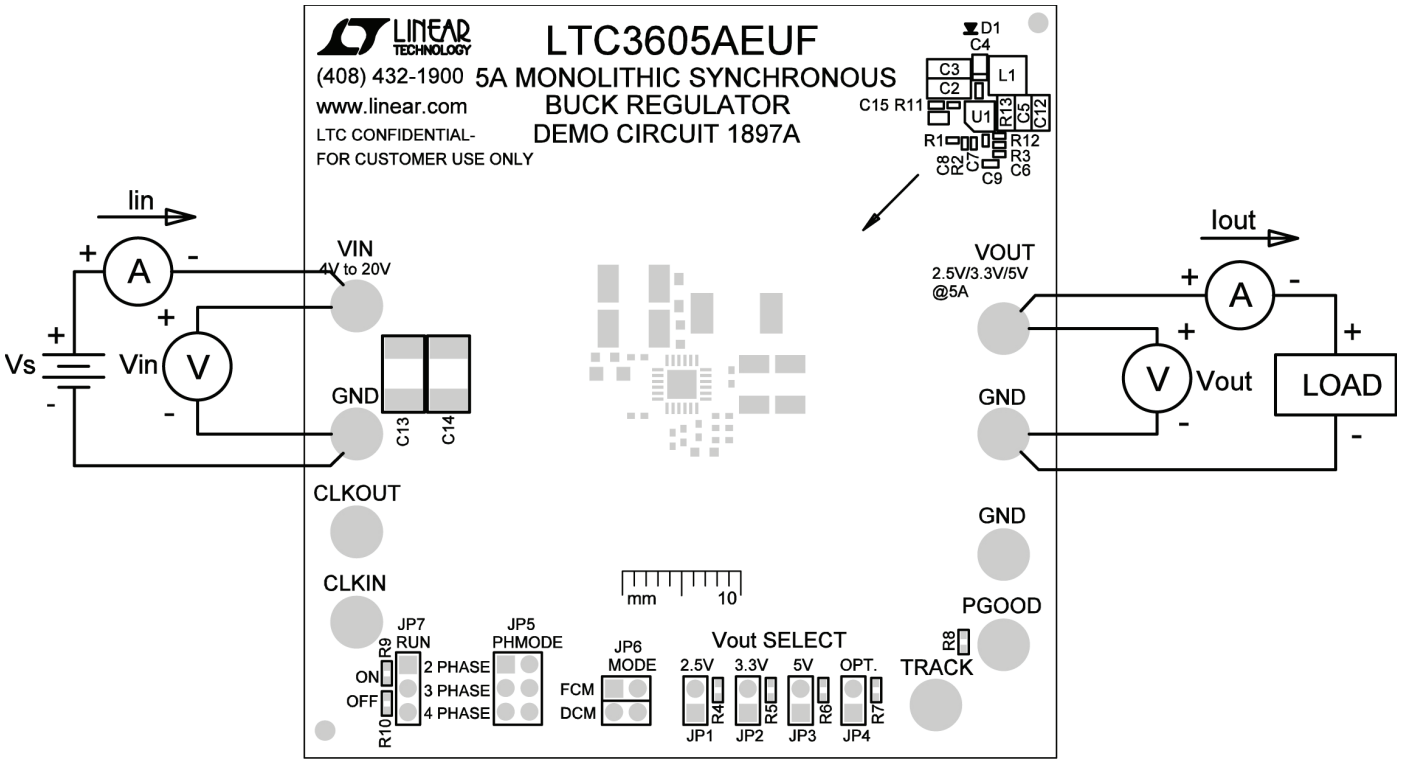


Figure 1. Proper Equipment Measurement Setup

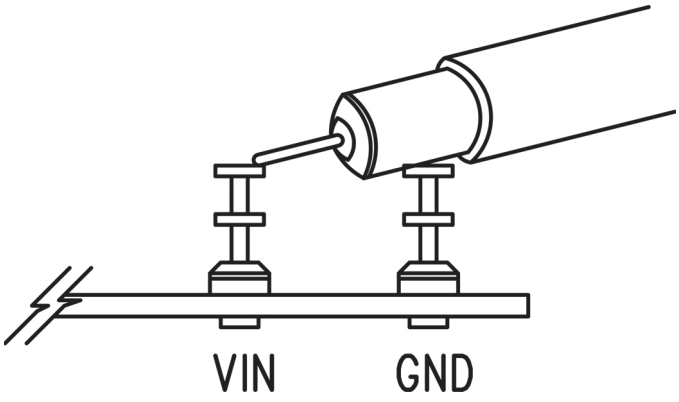


Figure 2. Measuring Input or Output Ripple

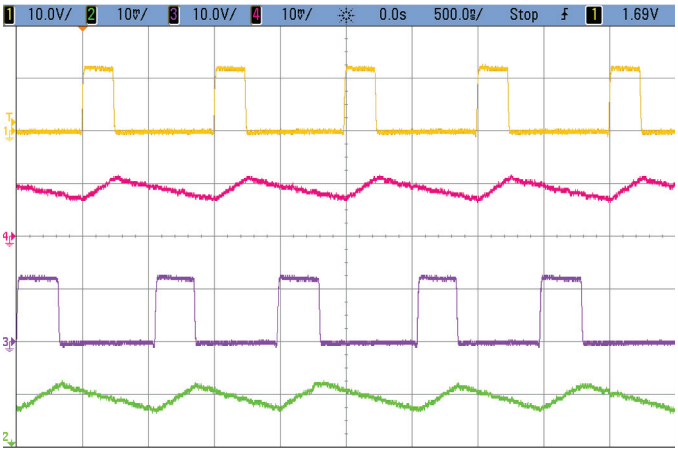
QUICK START PROCEDURE

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

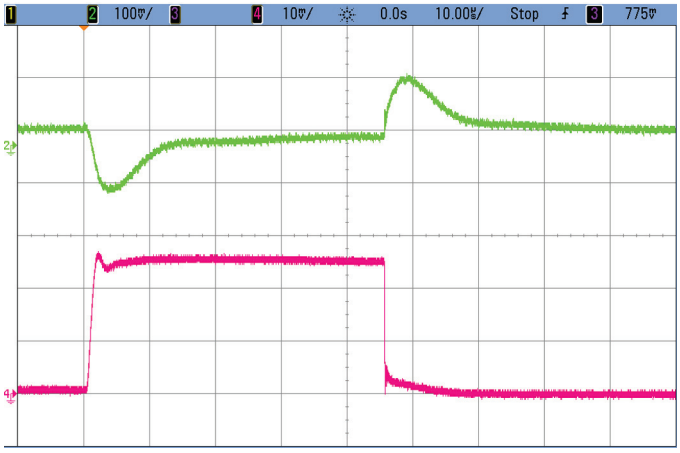
2-Phase Dual Output Waveforms



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

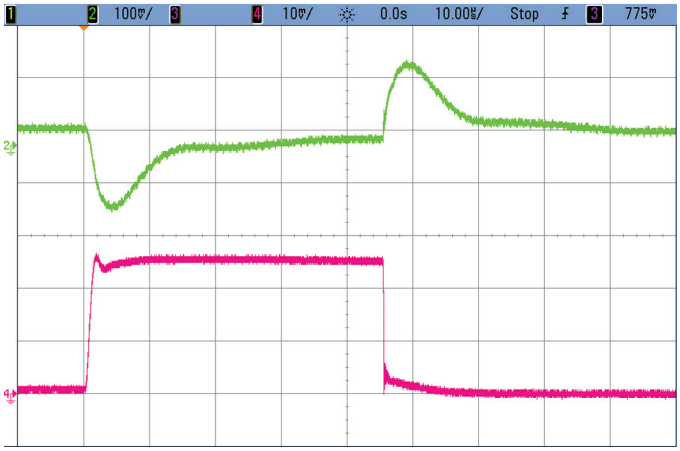
Load Step Response Waveforms



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

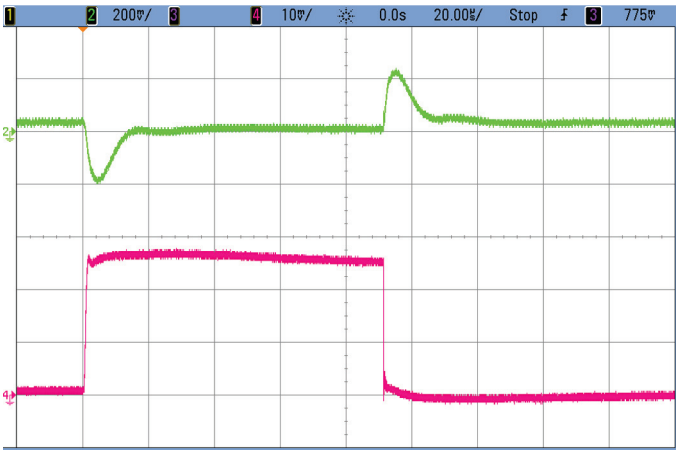


V_{IN} = 12V, V_{OUT} = 3.3V, 5A Load Step (0A to 5A)
Forced Continuous Mode, f_{SW} = 1MHz
Trace 2: Output Voltage (100mV/Div AC)
Trace 4: Output Current (2A/Div)

Figure 6. Load Step Response

QUICK START PROCEDURE

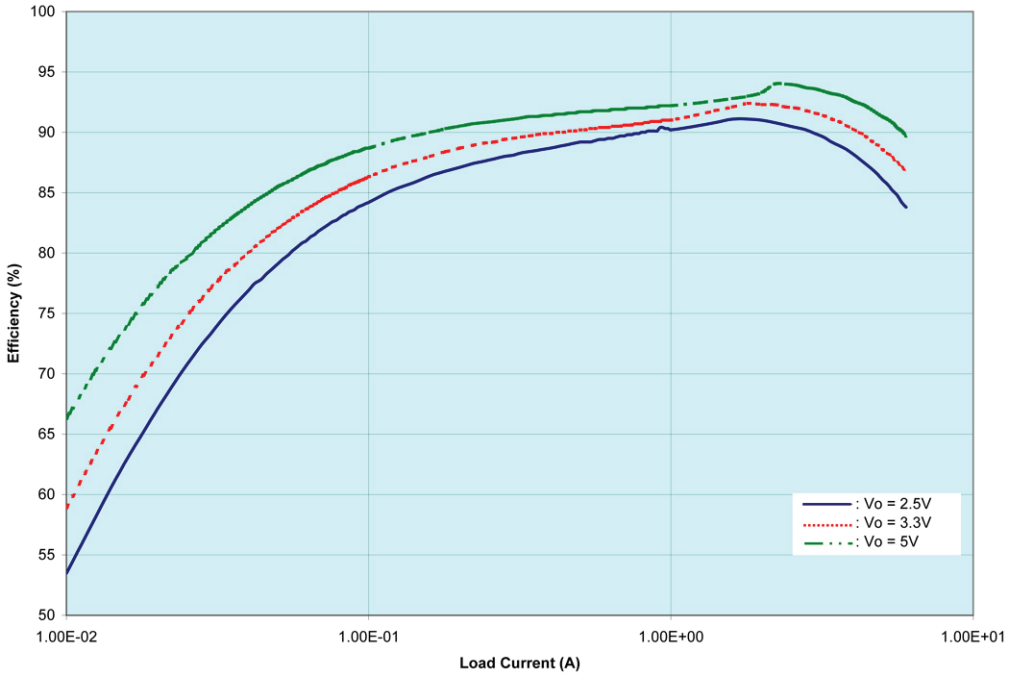
Load Step Response Waveforms



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 7. Load Step Response

Circuit Efficiency



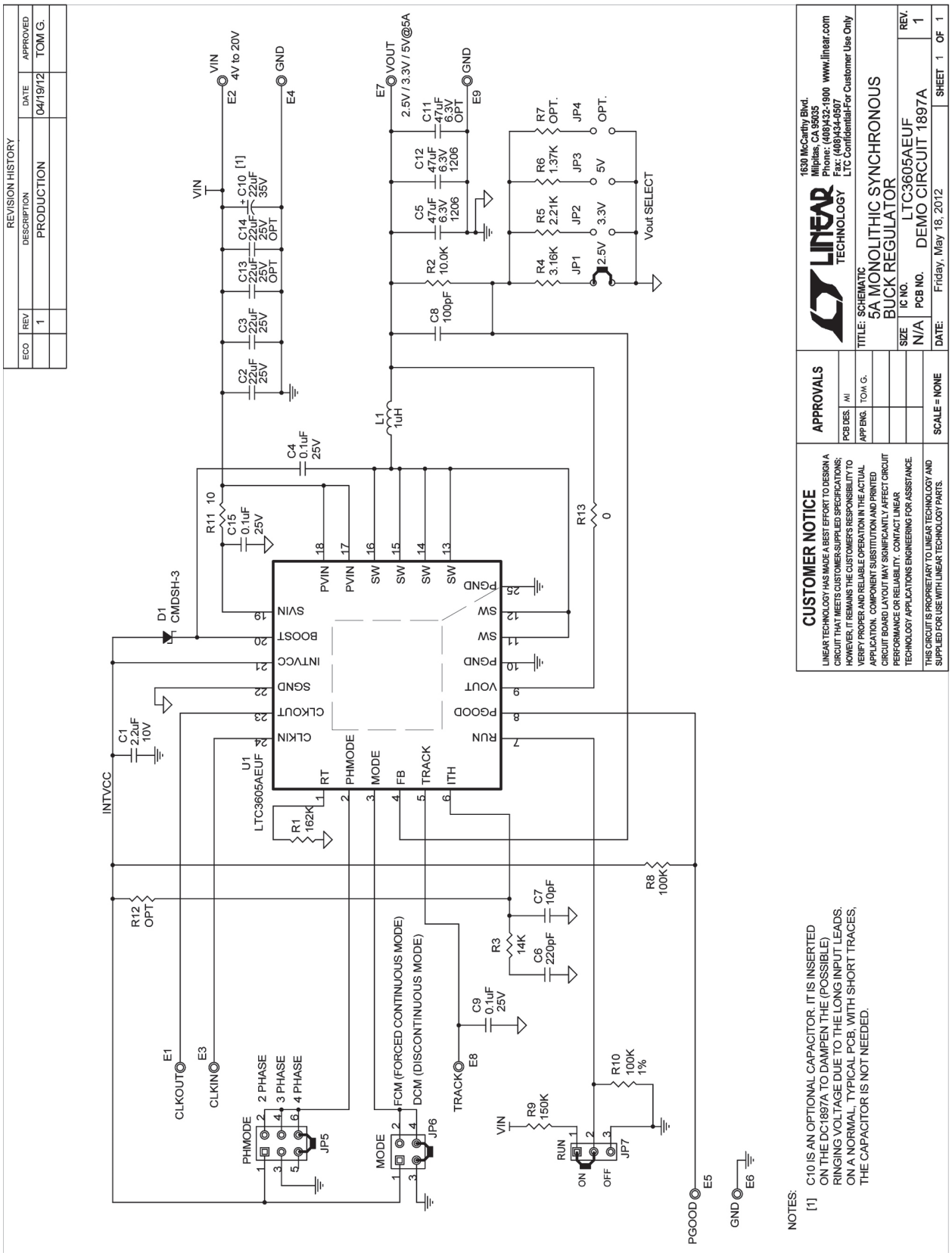
V_{IN} = 12V
Discontinuous Mode, f_{SW} = 1MHz

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% 6.3V X5R	TAIYO YUDEN JMK316BJ476ML-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 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	1	R8	RES, 0402 100k 5% 1/16W	VISHAY CRCW0402100KJNED
9	1	R9	RES, 0402 150k 1% 1/16W	VISHAY CRCW0402150KFKED
10	1	R10	RES, 0402 100k 1% 1/16W	VISHAY CRCW0402100KFKED
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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