LTC3634
15V Dual 3A Monolithic Step-Down Regulator Board for DDR Power

DESCRIPTION

Demonstration circuit 1839A is a dual output regulator focused specifically for DDR memory power applications. It's built based on the LTC3634, a high voltage dual channel, controlled on-time monolithic synchronous buck regulator. The DC1839A has an input voltage range of 3.6V to 15V. The output voltage of the first channel, V_{DDQ}, of the DC1839A has three fixed voltage settings; 1.5V, 1.8V, and 2.5V, and is capable of delivering up to 3A of output current. The second channel, V_{TT}, is set to regulate to half the voltage on the VDDQIN pin, which can be either the channel 1 output or an external reference voltage. It can source or sink a maximum of 3A. The LTC3634 also provides a 10mA buffered output of half VDDQIN – VTTR, which is used to provide the reference voltage needed for DDR applications. With the use of a timing resistor, the DC1839A can have its operating frequency programmed from 500kHz to 4MHz, or the DC1839A can be easily synchronized to an external clock, due to an internal phase-locked loop. The DC1839A V_{DDQ} output can operate in either Burst Mode® operation or forced continuous mode. In Burst Mode operation, which is the preferred mode of low load current operation, the DC supply current is typically only 1.3mA (both channels) at no load (sleep mode), and less than 15µA in shutdown. In Burst Mode operation or continuous mode operation, the DC1839A is a very efficient circuit at high load currents: over 80% for either channel. The LTC3634 is also capable of in-phase or 180° out-of-phase operation, and to allow its output to track an external voltage, either coincidentally or ratiometrically. The LTC3634 comes in a 28-pin QFN or leaded package, which each having an exposed pad on the bottom side of the IC for better thermal performance. All of these features make the DC1839A an ideal circuit for powering DDR memory applications.

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

PERFORMANCE SUMMARY (T_A = 25°C)

PARAMETER	CONDITIONS		VALUE
Minimum Input Voltage			3.6V
Maximum Input Voltage			15V
Output Voltage V_{OUT1} – V_{DDQ}	V_{IN} = 3.6V to 15V, I_{OUT1} = 0A to 3A		1.5V ±2% (1.47V to 1.53V)
			1.8V ±2% (1.764V to 1.836V)
			2.5V ±2% (2.45V to 2.55V)
Typical Output Ripple V_{DDQ}	V_{IN} = 12V, I_{OUT1} = 3A (20MHz BW)		< 20mV$_{P-P}$
Output Voltage V_{OUT2} – V_{TT}	V_{IN} = 3.6V to 15V, I_{OUT2} = 0A to ±3A	V_{OUT1} = 1.5V	0.75V ±3% (0.7275V to 0.7725V)
		V_{OUT1} = 1.8V	0.9V ±3% (0.873V to 0.927V)
		V_{OUT1} = 2.5V	1.25V ±3% (1.2125V to 1.2875V)
Typical Output Ripple V_{TT}	V_{IN} = 12V, I_{OUT2} = ±3A (20MHz BW)		< 20mV$_{P-P}$
Nominal Switching Frequencies	RT = 324k		1MHz
Burst Mode-to-CCM transition	Channel 1: V_{IN} = 12V, V_{OUT1} = 1.8V, f_{SW} = 1 MHz		I_{OUT1} = 1.6A
$INTV_{CC}$			3.3V
VTTR	VDDQIN = 2.5V		1.25V

QUICK START PROCEDURE

The DC1839A is easy to set up to evaluate the performance of the LTC3634. For a proper measurement equipment configuration, set up the circuit according to the diagram in Figure 1.

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 the proper scope probe technique in Figure 2.

Please follow the procedure outlined below for proper operation.

1. Connect the input power supply to the V_{IN} and GND terminals. Connect the loads between the V_{OUT} and GND terminals. Refer to Figure 1 for the proper measurement equipment setup.

   Before proceeding to operation, insert jumper shunts XJP1 and XJP2 into the OFF positions of headers JP1 and JP2, shunt XJP3 into the forced continuous mode (FCM) position of MODE header JP3, shunt XJP4 into the 180° (out-of-phase) position of PHASE header JP4, shunt XJP5 into the soft-start positions of TRACK/SS header JP5, and shunt XJP6 into the V_{OUT1} voltage options of choice of header JP6: 1.2V, 1.5V, or 1.8V.

2. Apply 5V at V_{IN}. Measure both V_{OUT}s; they should read 0V. If desired, one can measure the shutdown supply current at this point. The supply current should be less than 30μA in shutdown.

3. Turn on V_{OUT1}, V_{DDQ}, and V_{OUT2}, V_{TT}, by shifting shunts XJP1 and XJP2 from the OFF positions to the ON positions. Both output voltages should be within a tolerance of ±1%.

4. Vary the input voltage from 3.6V to 15V, the channel 1 load current from 0 to 3A, and the channel 2 load current from 0 to ±3A (The V_{TT} channel sinks as well as sources current. An easy way to test this capability is shown in the test set-up diagram; connect a variable resistor from V_{IN} to V_{OUT}, along with an ampmeter. The current will be V_{IN} minus V_{OUT} divided by the variable resistor value). V_{DDQ} output voltage tolerance should be within ±2%, whereas the output voltage tolerance of V_{TT} should be within ±3%.

5. Set the load current of both outputs to 3A and the input voltage to 12V, then measure each output ripple voltage (refer to Figure 2 for proper measurement technique); they should each measure less than 20mVAC. Also, observe the voltage waveform at either switch node (pins 16 and 17 for channel 1, and 23 and 24 for channel 2) of each regulator. (Both switch node waveforms should be rectangular in shape and 180°out-of-phase with each other). The switching frequencies should be between 800kHz and 1.2MHz (T = 1.25μs and 0.833μs).

6. With the board under proper operation, observe the load regulation, efficiency, in-phase operation (by changing jumper XJP4 to the 90° position), or Burst Mode operation (by changing jumper XJP3 to the Burst Mode position).

7. (Optional) Moving the zero ohm resistor at RV_{DDQ}, inserting it into R_{DDQIN}, and applying a voltage to turret V_{DDQIN} allows channel 2 output voltage (VTTR) to be adjusted to any desired voltage (to one-half the voltage at VDDQIN).

When finished, insert shunts XJP1 and XJP2 to the OFF position(s) and disconnect the power.

Warning: If the power for the demo board is carried in long leads, the input voltage at the part could ring, which could affect the operation of the circuit or even exceed the maximum voltage rating of the IC. To eliminate the ringing, a small Poscap capacitor (for instance, AVX part number TPSY226M035R0200) is inserted on the pads between the input power and return terminals on the bottom of the demo board. The (greater) ESR of the Poscap will dampen the (possible) ringing voltage due to the use of long input leads. On a normal, typical PCB, with short traces, this capacitor is not needed.

QUICK START PROCEDURE

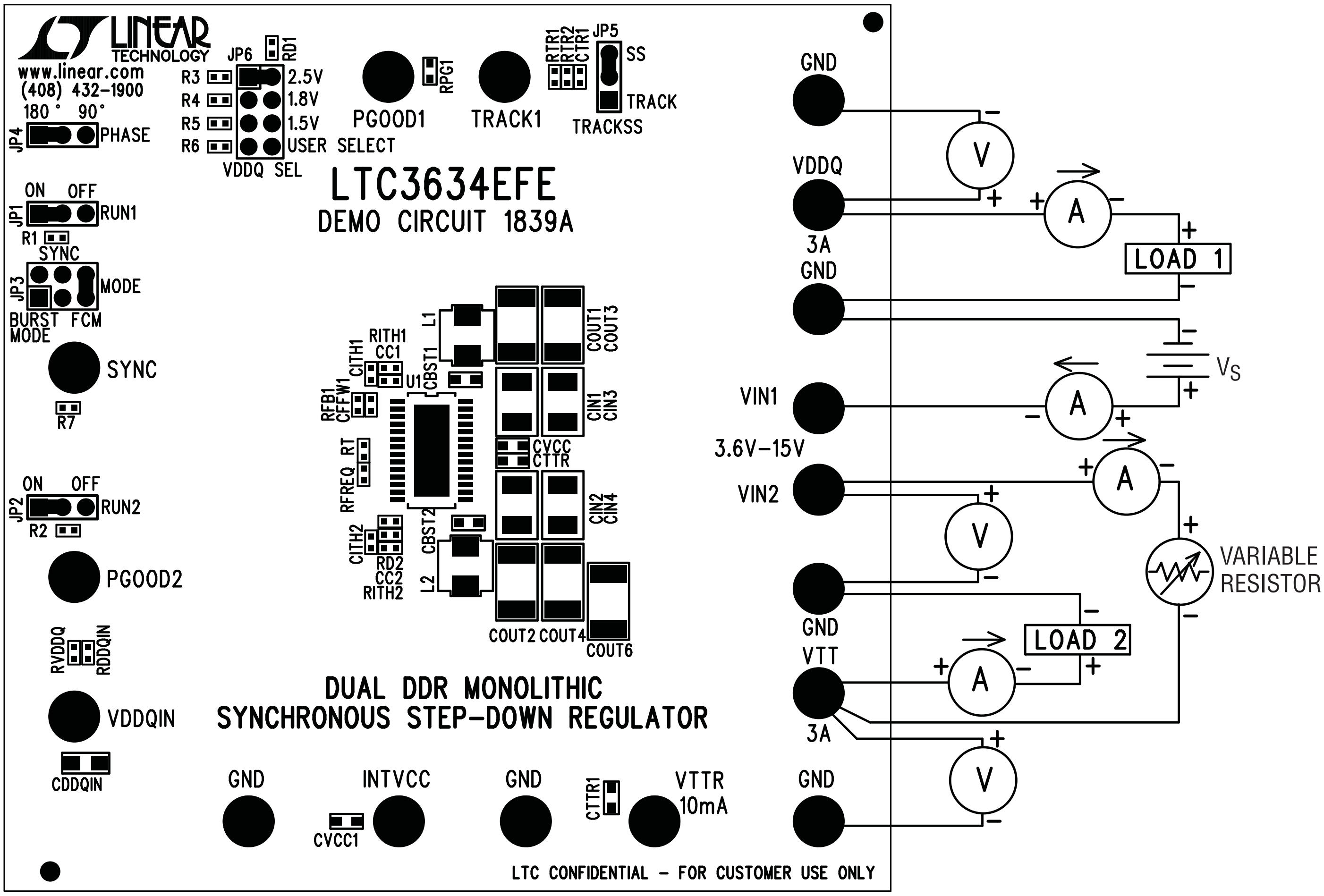


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

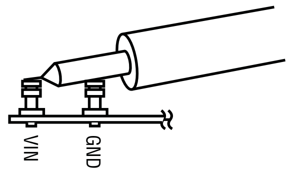


Figure 2. Measuring Input or Output Ripple

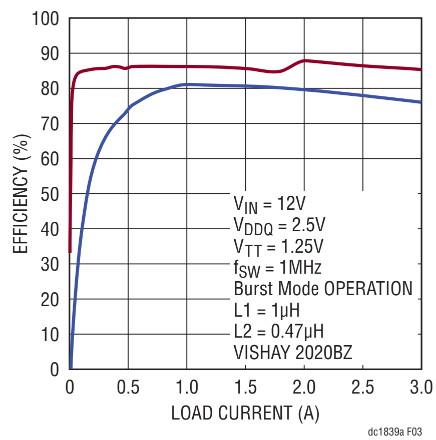
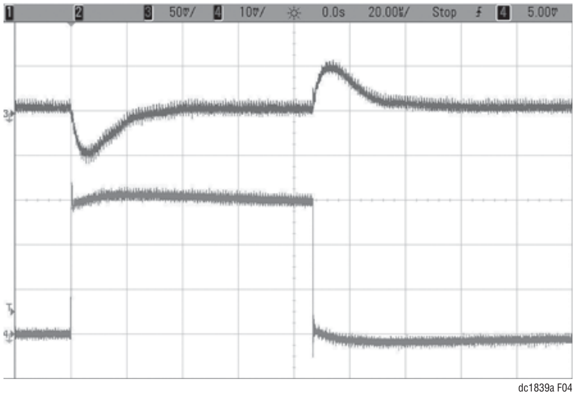


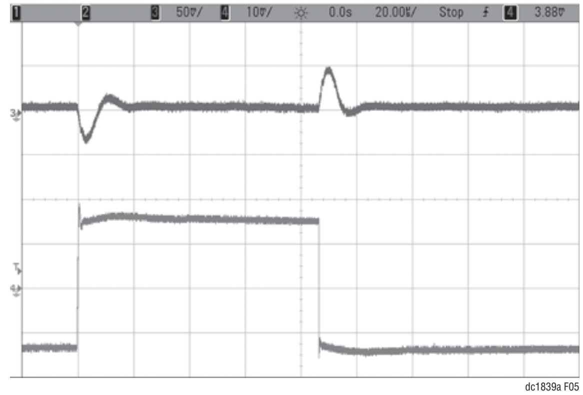
Figure 3. LTC3634 DC1839A Efficiency

QUICK START PROCEDURE



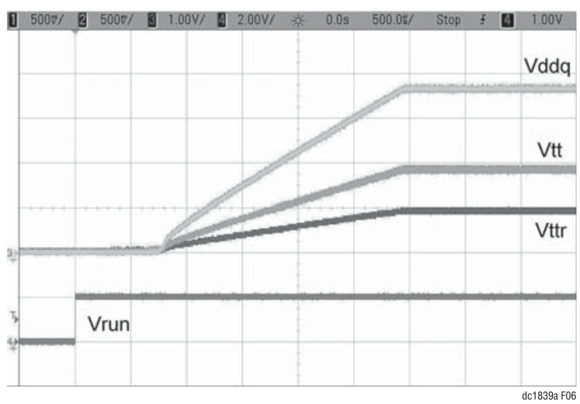
V_{IN} = 12V
V_{DDQ} = 1.8V
3A LOAD STEP (0A TO 3A)
FORCED CONTINUOUS MODE
f_{SW} = 1MHz
EXTERNAL COMPENSATION: R_{ITH1} = 18.2k, C_{ITH1} = 680pF
TRACE 3: OUTPUT VOLTAGE (50mV/DIV AC)
TRACE 4: OUTPUT CURRENT (1A/DIV)

Figure 4. V_{DDQ} Load Step Response



V_{IN} = 12V
V_{TT} = 0.9V
±3A LOAD STEP (–3A TO 3A)
FORCED CONTINUOUS MODE
f_{SW} = 1MHz
EXTERNAL COMPENSATION: R_{ITH2} = 15k, C_{ITH2} = 1000pF
TRACE 3: OUTPUT VOLTAGE (50mV/DIV AC)
TRACE 4: OUTPUT CURRENT (2A/DIV)

Figure 5. V_{TT} Load Step Response



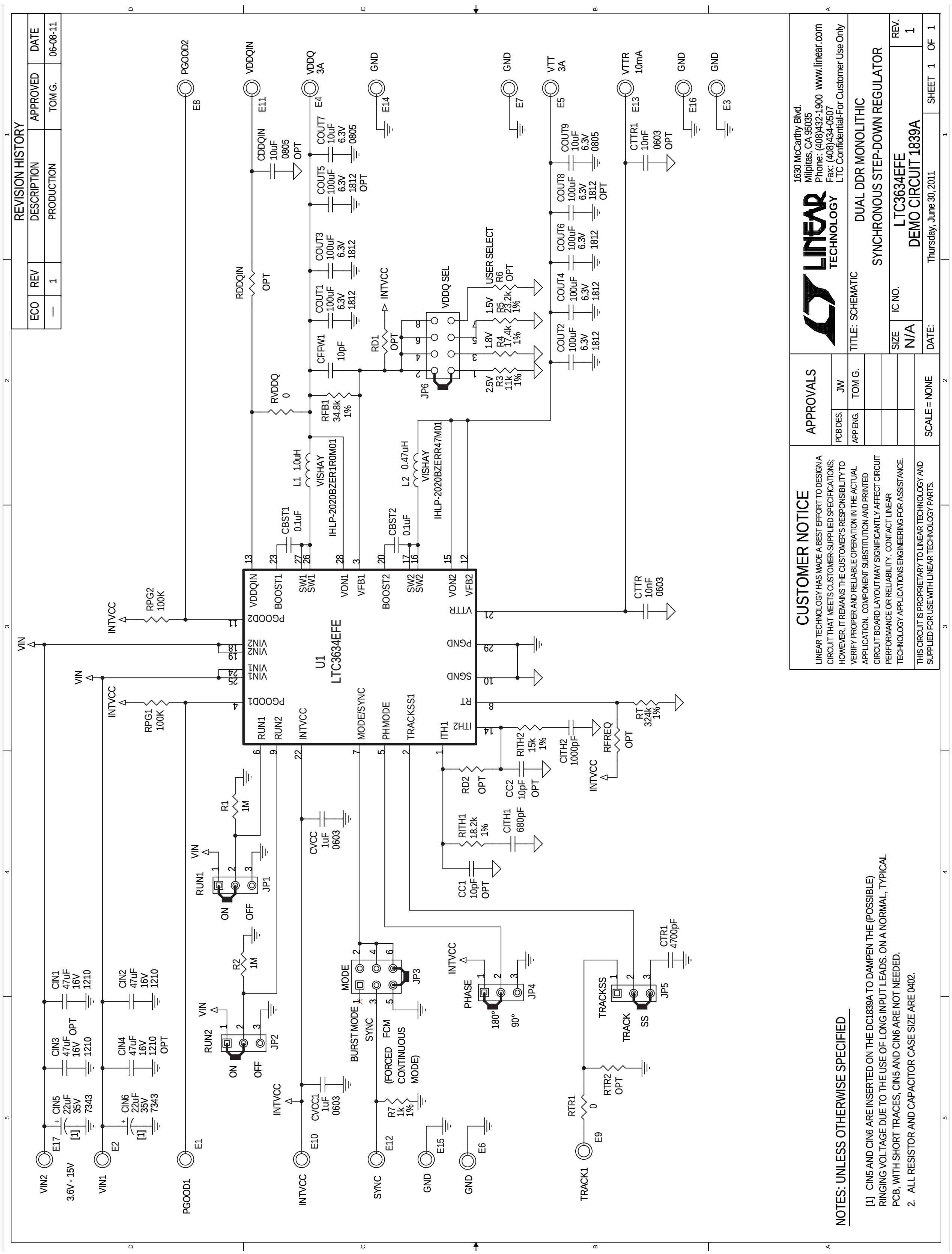
V_{IN} = 12V
V_{DDQ} = 1.8V
V_{TT} = 0.9V
3A LOAD (EACH)
FORCED CONTINUOUS MODE
f_{SW} = 1MHz
C_{SS} = 4700pF
TRACE 1: V_{DDQ} OUTPUT (500mV/DIV)
TRACE 2: V_{TT} OUTPUT (500mV/DIV)
TRACE 3: VTTR OUTPUT (1V/DIV)
TRACE 4: V_{RUN} VOLTAGE (2V/DIV)

Figure 6. LTC3634 DC1839A Start-Up with Soft-Start

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	CBST1, CBST2	CAP, 0603, 0.1µF, 10%, 50V, X7R	NIC NMC0603X7R104K50TRPF
2	1	CFFW1	CAP, 0402, 10pF, 5%, 25V, NPO	NIC NMC0402NPO100J25TRPF
3	2	CIN1, CIN2	CAP, 1210, 47µF, 20%, 16V, X5R	TAIYO YUDEN EMK325BJ476MM-T
4	1	CITH1	CAP, 0402, 680pF, 10%, 25V, X7R	AVX 04023C681KAT2A
5	1	CITH2	CAP, 0402, 1000pF, 10%, 25V, X7R	AVX 04023C102KAT2A
6	5	COUT1-COUT4, COUT6	CAP, 1812, 100µF, 20%, 6.3V, X5R	TDK C4532X5R0J107M
7	1	CTTR	CAP, 0603, 10nF, 10%, 16V, X7R	AVX 0603YC103KAT2A
8	1	CVCC	CAP, 0603, 1µF, 10%, 16V, X5R	NIC NMC0603X5R105K16TRPF
9	1	L1	IND, 1.0µH	VISHAY IHLP2020BZER1R0M01
10	1	L2	IND, 0.47µH	VISHAY IHLP2020BZERR47M01
11	1	RFB1	RES, 0402, 34.8kΩ, 1%, 1/16W	NIC NRC04F3482TRF
12	1	RITH1	RES, 0402, 18.2kΩ, 1%, 1/16W	VISHAY CRCW040218K2FKED
13	1	RITH2	RES, 0402, 15kΩ, 1%, 1/16W	VISHAY CRCW040215K0FKED
14	1	RT	RES, 0402, 324kΩ, 1%, 1/16W	NIC NRC04F3243TRF
15	1	RVDDQ	RES, 0402, 0Ω, JUMPER	NIC NRC04Z0TRF
16	1	R3	RES, 0402, 11kΩ, 1%, 1/16W	NIC NRC04F1102TRF
17	1	U1	IC, MONOLITHIC SYNCHRONOUS STEP-DOWN REGULATOR	LINEAR TECH LTC3634EFE
Additional Demo Board Circuit Components				
1	0	CC1, CC2 OPTION	CAP, 0402, 10pF, 5%, 25V, NPO	NIC NMC0402NPO100J25TRPF
2	0	CDDQIN OPTION	CAP, 0805, 10µF, 10%, 6.3V, X5R OPTION	NIC NMC0805X5R106K6.3TRPLP3KF
3	0	CIN3, CIN4 OPTION	CAP, 1210, 47µF, 20%, 16V, X5R	TAIYO YUDEN EMK325BJ476MM-T
4	2	CIN5, CIN6	CAP, TANT. 7343, 22µF, 20%, 35V	AVX TPSY226M035R0200
5	0	COUT5, COUT8 OPTION	CAP, 1812, 100µF, 20%, 6.3V, X5R	TDK C4532X5R0J107M OPTION
6	2	COUT7, COUT9	CAP, 0805, 10µF, 10%, 6.3V, X5R	NIC NMC0805X5R106K6.3TRPLP3KF
7	1	CTR1	CAP, 0402, 4700pF, 10%, 50V, X7R	TDK C1005X7R1H472K
8	0	CTTR1	CAP, 0603, 10nF, 10%, 16V, X7R	AVX 0603YC103KAT2A OPTION
9	1	CVCC1	CAP, 0603, 1µF, 10%, 16V, X5R	NIC NMC0603X5R105K16TRPF
10	0	RD1, RTR2, RD2, R6, RFREQ, RDDQIN OPTION	RES, 0402	OPTION
11	2	RPG1, RPG2	RES, 0402, 100kΩ, 5%, 1/16W	NIC NRC04J104TRF
12	1	RTR1	RES, 0402, 0Ω, JUMPER	NIC NRC04Z0TRF
13	2	R1, R2	RES, 0402, 1MΩ, 5%, 1/16W	NIC NRC04J105TRF
14	1	R4	RES, 0402, 17.4kΩ, 1%, 1/16W	NIC NRC04F1742TRF
15	1	R5	RES, 0402, 23.2kΩ, 1%, 1/16W	NIC NRC04F2322TRF
16	1	R7	RES, 0402, 1kΩ, 1%, 1/16W	NIC NRC04F1001TRF
Hardware/Components (For Demo Board Only)				
1	17	E1-E17	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
2	4	JP1, JP2, JP4, JP5	HEADER, 3-PIN, 2mm	SAMTEC TMM-103-02-L-S
3	1	JP3	HEADER, 3-PIN, DBL ROW 2mm	SAMTEC TMM 103-02-L-D
4	1	JP6	HEADER, 4-PIN, DBL ROW 2mm	SAMTEC TMM 104-02-L-D
5	6	JP1-JP6	SHUNT, 2mm	SAMTEC 2SN-BK-G

SCHEMATIC DIAGRAM



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