LT8253
40V USB Type-C Power Delivery 4-switch Buck-Boost Controller

DESCRIPTION

Demonstration circuit 3004A is a 40V 4-switch buck-boost controller configured for automotive USB-C power delivery charging applications supporting up to 60W output power capability featuring the LT®8253. LT8253 powers devices connected through the USB-C port at voltages between 3.3V and 21V at up to 3A when V_{IN} is between 9V and 18V. DC3004A will run down to $6V_{IN}$ with reduced output power capability and can operate through up to 36V input transient conditions. DC3004A runs at 400kHz switching frequency and features spread spectrum frequency modulation (SSFM) for reduced EMI. With SSFM enabled, EMI generated by DC3004A falls below the CISPR25 Class 5 limits.

The LT8253 has an operating input voltage range of 4V to 40V. LT8253 can regulate an output as a boost, a buck, or a 4-switch buck-boost controller. It has an adjustable switching frequency between 150kHz and 650kHz, with an option for external frequency synchronization or ±15% spread spectrum frequency modulation.

DC3004A utilizes Cypress Semiconductor's CCG3PA USB-C port controller (CYPD3196) to interface between connected USB-C devices and the LT8253 power circuitry in order to comply with the latest USB Type-C and power delivery standards. This port controller device is powered directly from the $INTV_{CC}$ pin of the LT8253. The CCG3PA facilitates the power contract negotiation between the connected device and DC3004A and adjusts the voltage at the FB divider to set the output voltage accordingly. The LT8253+CCG3PA system monitors input voltage, output voltage and current, and measured temperature on board to help adjust output power capabilities based off measured operation parameters, as well as provide output overvoltage, undervoltage, and overcurrent protection.

The DC3004A is preloaded with firmware configured to support output power delivery up to 60W using the latest USB Power Delivery 3.0 protocol, and offers the following PDO/PPS output configuration options:

PDO: 5V@3A, 9V@3A, 15V@3A, 20V@3A

PPS: 3.3-11V@3A, 3.3-16V@3A, 3.3-21V@3A

DC3004A firmware is also configured to support legacy charge profiles including BC 1.2, QC 4.0 and 3.0, AFC, and Apple 2.4A charging. Firmware can be updated to support different PDO voltage and power levels. Contact factory apps for support.

The LT8253 data sheet gives a complete description of the part, operation, and applications information. The data sheet must be read in conjunction with this demo manual for DC3004A. The LT8253JUFDM is assembled in a 28-lead plastic side-wettable QFN (UFDM) package with a thermally enhanced exposed ground pad. Proper board layout is essential for maximum thermal performance. See the data sheet section "PC Board Layout Checklist".

Design files for this circuit board are available.

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX
CISPR25 Conducted Emissions (Class 5 Limits) CISPR25 Radiated Emissions (Class 5 Limits)	$12V_{IN}$, $20V_{OUT}$, $3A_{OUT}$ (60W), SSFM = ON		PASS PASS	
Input Voltage V_{IN} Range	P_{OUT}, MAX = 60W P_{OUT}, MAX = 30W	9V 6V		18V 9V
Switching Frequency (f_{SW})	R3 = 100k, JP1 = NO SSFM/SYNC R3 = 100k, JP1 = SSFM ON	 340kHz	400kHz	 460kHz
Output Voltage	9V > V_{IN} > 18V, TNTC < 80°C*	3.3V		21V
Output Power	9V > V_{IN} > 18V, TNTC < 80°C*			60W
Efficiency	V_{IN} =12V, V_{OUT} = 20V, I_{OUT} = 3A, JP1 = SSFM ON		94.3%	
V_{IN} Undervoltage Lockout (UVLO) Falling	R30 = 1M, R29 = 59k		6.0V	
V_{IN} Enable Turn-On (EN) Rising	R30 = 1M, R29 = 59k		6.75V	

QUICK START PROCEDURE

DC3004A is easy to set up to evaluate the performance of the LT8253. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

NOTE: Make sure that the voltage applied to V_{IN} does not exceed 40V, which is the voltage rating for the input side MOSFETs.

1. With power off, connect a power supply to the V_{IN} and GND terminals of DC3004A. Include voltage and current meters as shown if desired.
2. Connect DC3004A to a power adapter tester tool using a USB Type-C cable. Attach a variable voltage/current load to the power adapter tester. Include voltage and current meters as shown if desired.
3. After all connections are made. Turn on the power supply and verify that the input voltage is between 9V and 18V.
4. Configure the power adapter tester to select the desired V_{BUS} voltage. Adjust variable load to consume no more than 3A.

QUICK START PROCEDURE

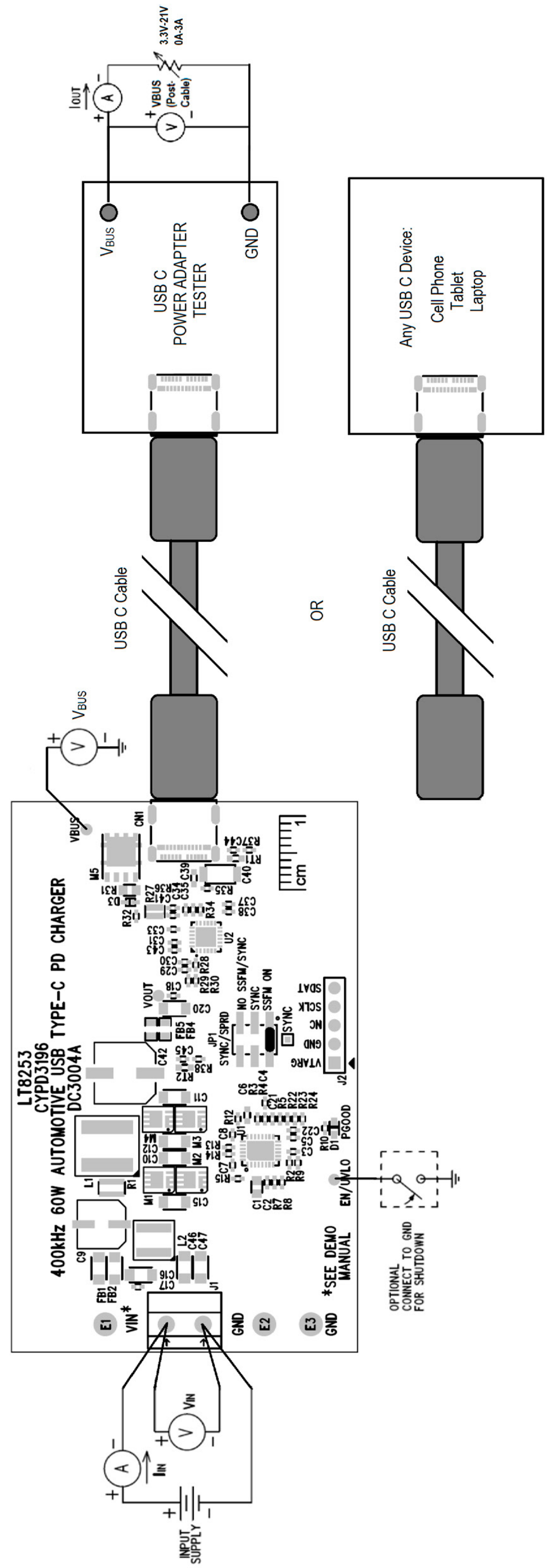
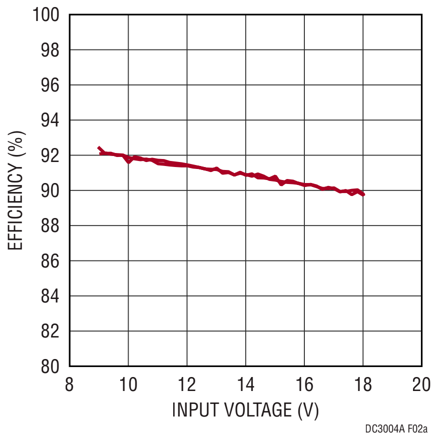
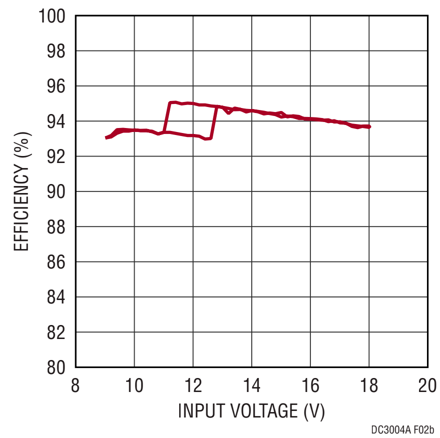


Figure 1. Test Procedure Setup Drawing for DC3004A

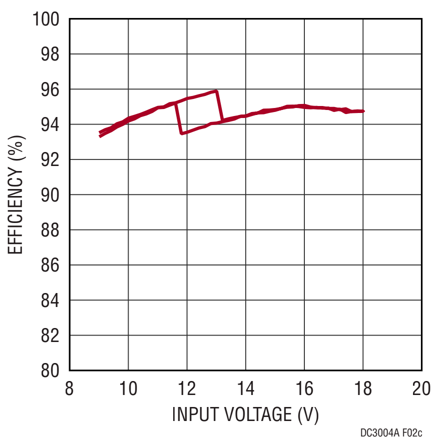
TEST RESULTS



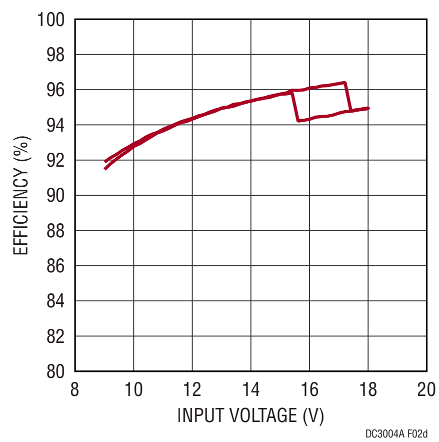
(a) 15W Output Efficiency V_{OUT} = 5V, I_{OUT} = 3A, SSFM = ON



(b) 27W Output Efficiency V_{OUT} = 9V, I_{OUT} = 3A, SSFM = ON



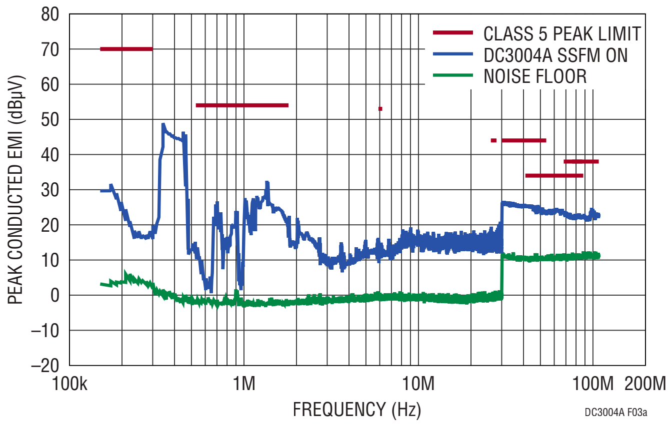
(c) 45W Output Efficiency V_{OUT} = 15V, I_{OUT} = 3A, SSFM = ON



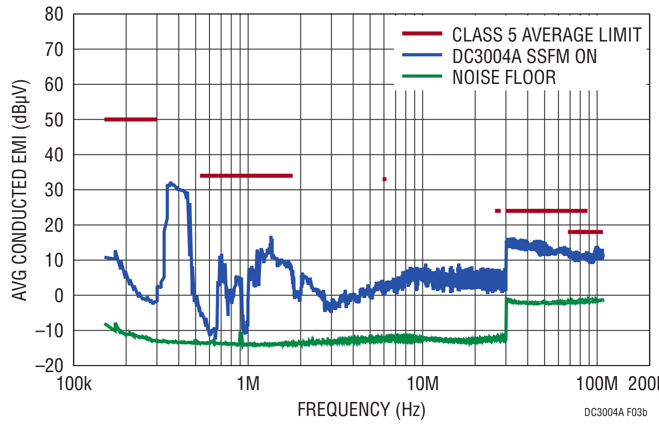
(d) 60W Output Efficiency V_{OUT} = 20V, I_{OUT} = 3A, SSFM = ON

Figure 2. DC3004A Efficiency vs Input Voltage

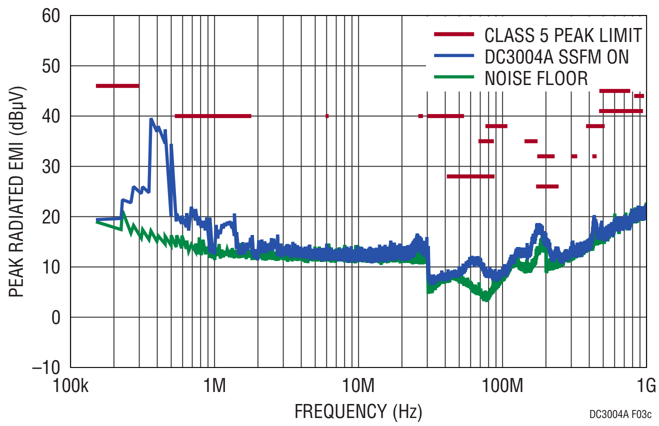
TEST RESULTS



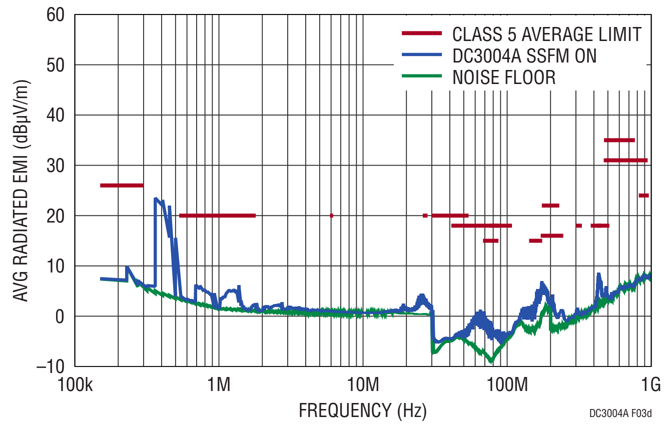
(a) CISPR25 Conducted Emissions with Class 5 Peak Limits



(b) CISPR25 Conducted Emissions with Class 5 Avg Limits



(c) CISPR25 Radiated Emission with Class 5 Peak Limits



(d) CISPR25 Radiated Emissions with Class 5 Avg Limits

Figure 3. DC3004A 60W Output Conducted and Radiated EMI Results with CISPR25 Class 5 Limit Lines

THERMAL IMAGE

An example thermal image shows the temperature distribution on DC3004A. The test is done in still air at room temperature (23°C) with spread spectrum frequency modulation (SSFM) enabled. Figure 4 shows a result when the input voltage is 12V and the output is configured for a 60W load; the highest temperature is under 68°C. No heatsink or forced airflow is used for these measurements.

*Local temperature is measured by CCG3PA using NTC circuitry. Output power is programmed to fold back at ~80°C measured. This can be reprogrammed for higher temperature operation.

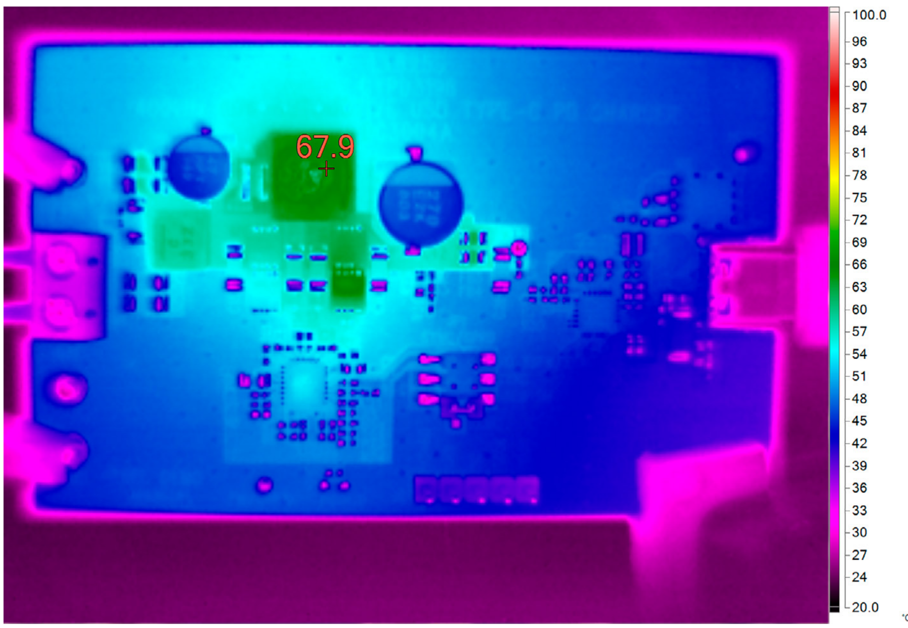


Figure 4. Board Temperature with 60W Output (V_{IN} = 12V, V_{OUT} = 20V, I_{OUT} = 3A, SSFM = ON, T_{AMB} = 23°C, No Heatsink/Forced Air)

THERMAL IMAGE

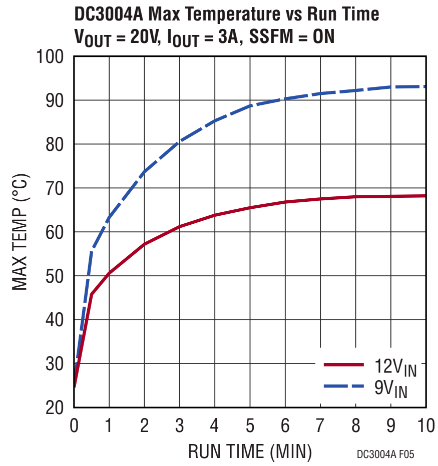


Figure 5. Max Temperature on DC3004A Over Time for Both $12V_{IN}$ and $9V_{IN}$ Conditions

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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