

## LT8253A

# 40V USB Type-C Power Delivery 2MHz 4-Switch Buck-Boost Controller

## DESCRIPTION

Demonstration circuit 2949A is a 40V 4-Switch Buck-Boost Controller configured for automotive USB-C PD charging applications supporting up to 45W output power capability featuring the [LT®8253A](#). LT8253A powers devices connected through the USB-C port at voltages between 3.3V and 16V at up to 3A when  $V_{IN}$  is between 9V and 18V. DC2949A will run down to 6V at its input with reduced output power capability and can operate through up to 36V input transient conditions. DC2949A runs at 2MHz switching frequency and features spread spectrum frequency modulation (SSFM) for reduced EMI.

The LT8253A has an operating input voltage range of 4V to 40V. LT8253A can regulate an output as a boost, a buck, or a 4-switch buck-boost controller. LT8253A has an adjustable switching frequency between 600kHz and 2MHz, with an option for external frequency synchronization or  $\pm 25\%$  spread spectrum frequency modulation.

DC2949A utilizes a USB-C port controller (CYPD3196) to interface between connected USB-C devices and the LT8253A power circuitry in order to comply with the latest USB Type-C and PD standards. This port controller device is powered directly from the  $INTV_{CC}$  pin of the LT8253A. The port controller facilitates the power contract negotiation between the connected device and DC2949A and adjusts the voltage at the FB divider to set the output voltage accordingly. The LT8253A 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 DC2949A is preloaded with firmware configured to support output power delivery up to 45W using the latest USB PD 3.0 protocol, and offers the following PDO/PPS output configuration options:

PDO: 5V AT 3A, 9V AT 3A, 15V AT 3A

PPS: 3.3V–5.9V AT 3A, 3.3–11V AT 3A, 3.3–16V AT 3A

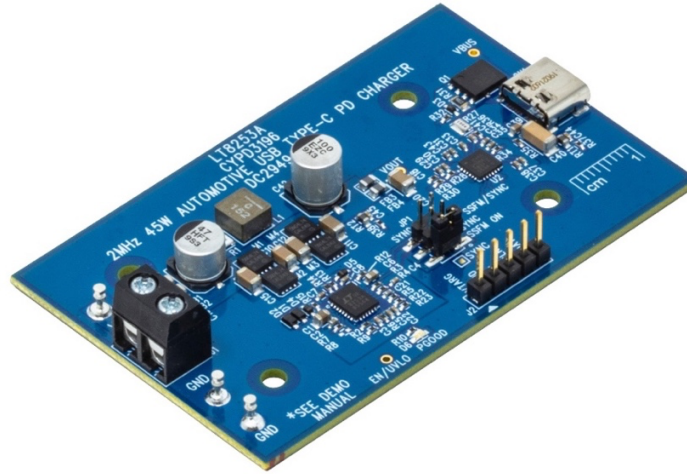
DC2949A firmware is also configured to support legacy charge profiles including BC 1.2, QC 4.0 and 3.0, AFC, and Apple 2.4A charging. Firmware can be updated to support different PDO voltage and power levels. Contact factory apps for support.

The LT8253A 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 DC2949A. The LT8253AJUFDM 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.](#)**

All registered trademarks and trademarks are the property of their respective owners.

## BOARD PICTURE



## PERFORMANCE SUMMARY

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

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Input Voltage $V_{IN}$ Range	$P_{OUT,MAX} = 45\text{W}$	9		18	V
	$P_{OUT,MAX} = 30\text{W}$	6		9	V
Switching Frequency ( $f_{SW}$ )	$R3 = 100\text{k}$ , JP1 = NO SSFM/SYNC		2		MHz
	$R3 = 100\text{k}$ , JP1 = SSFM ON	2		2.5	MHz
Output Voltage	$9\text{V} < V_{IN} < 18\text{V}$ , $T_{NTC} < 80^\circ\text{C}^*$	3.3		16	V
Output Power	$9\text{V} < V_{IN} < 18\text{V}$ , $T_{NTC} < 80^\circ\text{C}^*$			45	W
Efficiency	$V_{IN} = 12\text{V}$ , $V_{OUT} = 15\text{V}$ , $I_{OUT} = 3\text{A}$ , JP1 = SSFM ON EMI Filters Installed/SSFM ON		93.8%		
$V_{IN}$ Undervoltage Lockout (UVLO) Falling	$R30 = 1\text{M}$ , $R29 = 59\text{k}$		6.0		V
$V_{IN}$ Enable Turn-On (EN) Rising	$R30 = 1\text{M}$ , $R29 = 59\text{k}$		6.75		V

\*Local temperature is measured by CCG3PA using NTC circuitry. Output power is programmed to fold back at  $\sim 80^\circ\text{C}$  measured. This can be reprogrammed for higher temperature operation.

## QUICK START PROCEDURE

DC2949A is easy to set up to evaluate the performance of the LT8253A. 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.

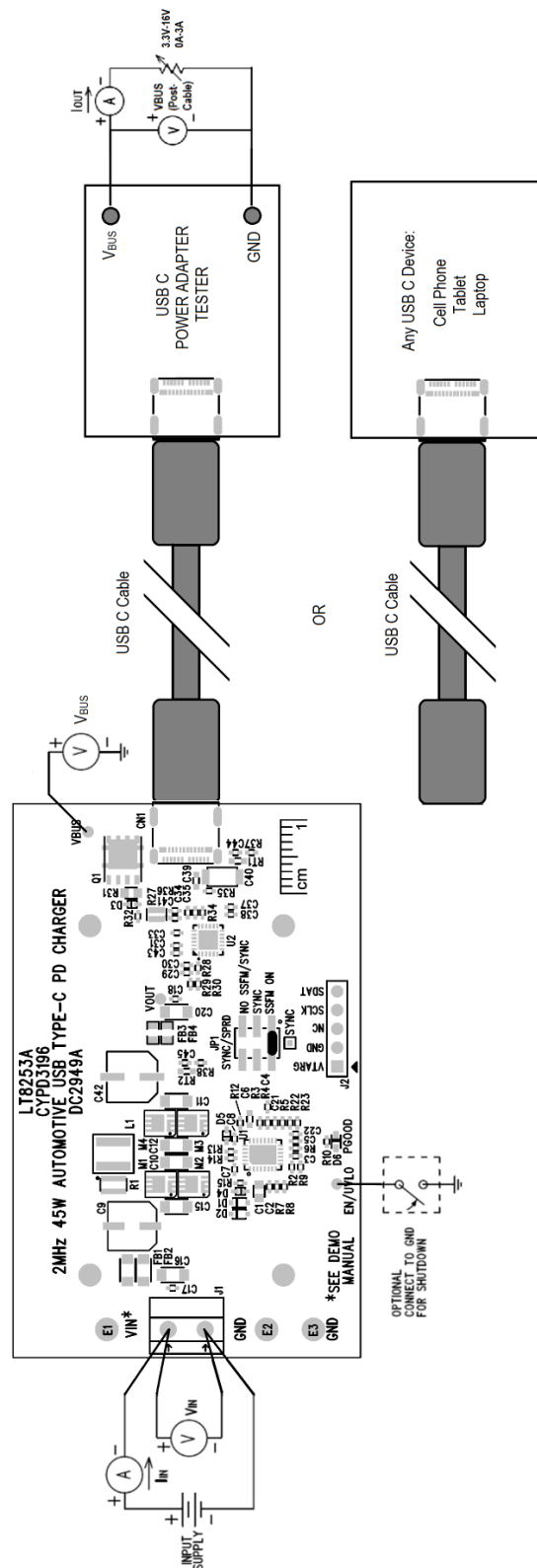
With power off, connect a power supply to the  $V_{IN}$  and GND terminals of DC2949A. Include voltage and current meters as shown if desired.

Connect DC2949A 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.

After all connections are made. Turn on the power supply and verify that the input voltage is between 9V and 18V.

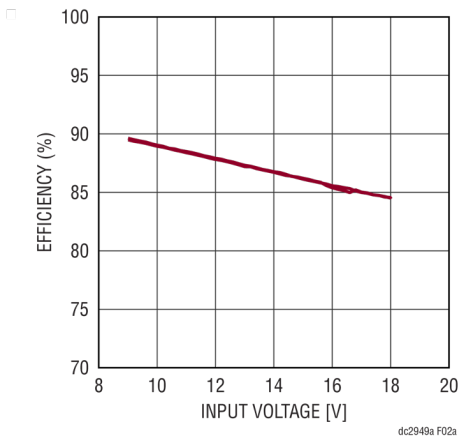
Configure the power adapter tester to select the desired  $V_{BUS}$  voltage. Adjust variable load to consume no more than 3A.

## QUICK START PROCEDURE

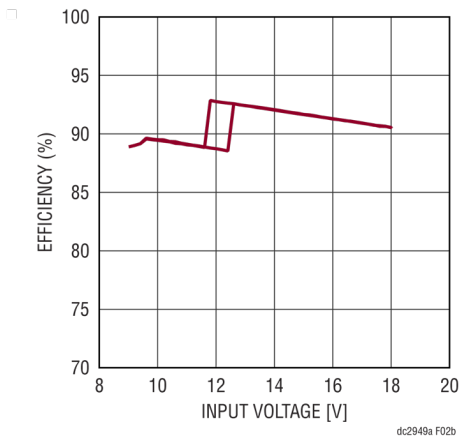


**Figure 1. Test Procedure Setup Drawing for DC2949A**

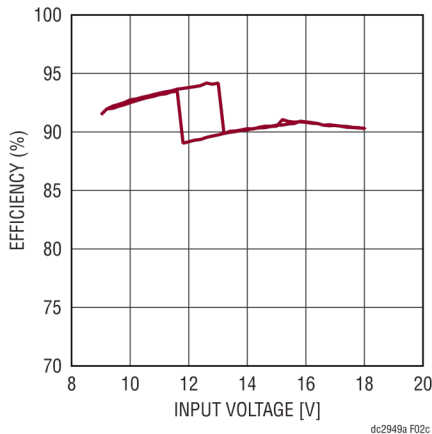
TEST RESULTS



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



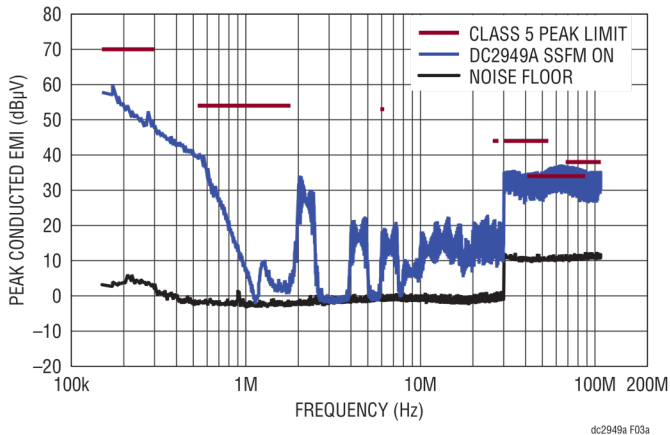
(b) 27W Output Efficiency,  $V_{OUT} = 9V$ ,  $I_{OUT} = 3A$ , SSFM = ON



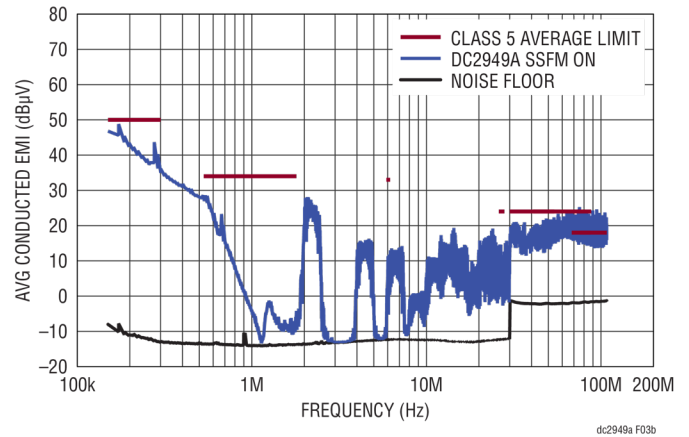
(c) 45W Output Efficiency,  $V_{OUT} = 15V$ ,  $I_{OUT} = 3A$ , SSFM = ON

Figure 2. DC2949A Efficiency vs Input Voltage

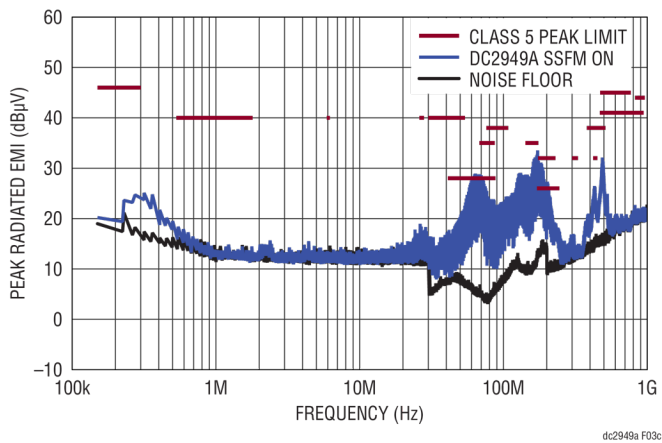
# TEST RESULTS



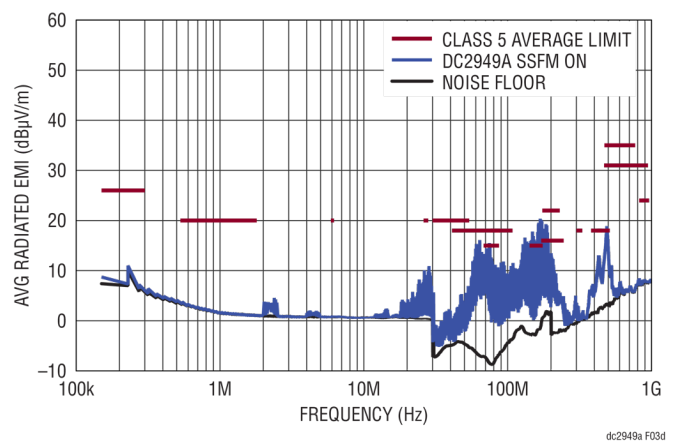
(a) CISPR25 Conducted Emissions with Class 5 Peak Limits



(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. DC2949A 45W Output Conducted and Radiated EMI Results with CISPR25 Class 5 Limit Lines

## THERMAL IMAGE

An example thermal image shows the temperature distribution on DC2949A. The test is done in still air at room temperature (23°C) with spread spectrum frequency modulation (SSFM) enabled and EMI filters installed. Figure 4 shows a thermal image of DC2949A operating at 12V<sub>IN</sub> configured for a 15V 3A (45W) output load. No heatsink or forced airflow is used for these

measurements. Max temperature is observed to be lower at 9V<sub>IN</sub> due to 2-switch boost operation.

**NOTE:** 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.

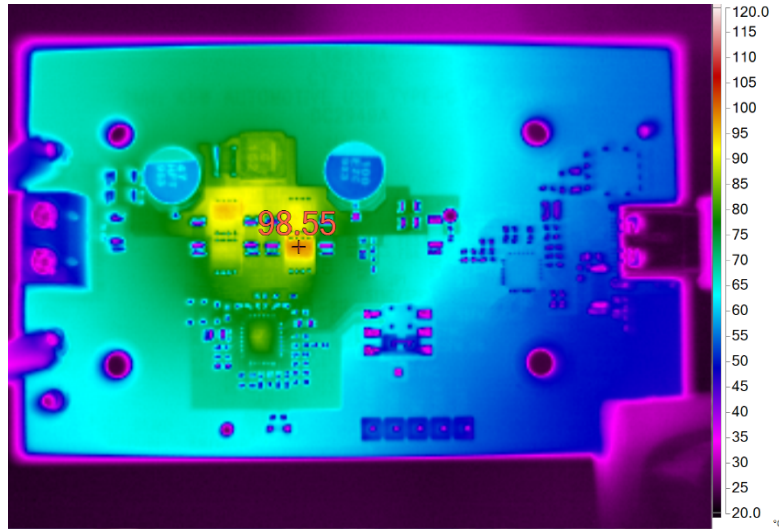
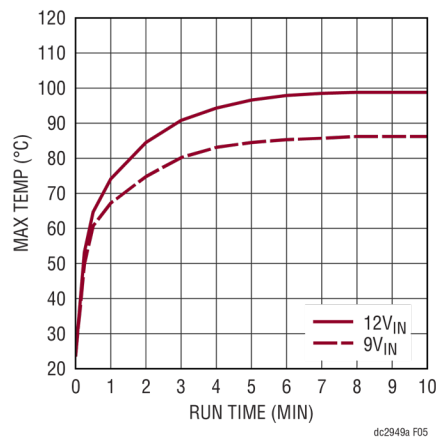


Figure 4. Board Temperature with 45W Output ( $V_{IN} = 12V$ ,  $V_{OUT} = 15V$ ,  $I_{OUT} = 3A$ , SSFM = ON,  $T_{AMB} = 23^{\circ}C$ , No Heatsink/Forced Air)



dc2949a F05

DC2949A, Max Temperature vs Run Time,  $V_{OUT} = 15V$ ,  $I_{OUT} = 3A$ , SSFM = ON

Figure 5. Max Temperature on DC2949A Over Time for both 12V<sub>IN</sub> and 9V<sub>IN</sub> Conditions

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	1	C1	CAP., 1 $\mu$ F, X7R, 50V, 10%, 0805, AEC-Q200	MURATA, GCM21BR71H105KA03L
2	2	C10, C15	CAP., 10 $\mu$ F, X5R, 50V, 10%, 1206, AEC-Q200	MURATA, GRT31CR61H106KE01L
3	2	C11, C12	CAP., 10 $\mu$ F, X7R, 25V, 10%, 1206, AEC-Q200	TAIYO YUDEN, TMK316AB7106KLHT
4	1	C2	CAP., 4.7 $\mu$ F, X5R, 6.3V, 20%, 0402, AEC-Q200	TAIYO YUDEN, JMK105BBJ475MVFH
5	1	C21	CAP., 180pF, C0G/NP0, 50V, 5%, 0402	MURATA, GRM1555C1H181JA01D
6	1	C22	CAP., 1000pF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H102KA37D
7	3	C29, C34, C43	CAP., 1 $\mu$ F, X5R, 25V, 10%, 0402, AEC-Q200	MURATA, GRT155R61E105KE01D
8	1	C3	CAP., 0.47 $\mu$ F, X5R, 25V, 10%, 0402, AEC-Q200	MURATA, GRT155R61E474KE01D
9	4	C30, C31, C33, C35	CAP., 0.1 $\mu$ F, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E104KE02D
10	2	C37, C38	CAP., 390pF, X7R, 50V, 10%, 0402, AEC-Q200	KEMET, C0402C391K5RACAUTO
11	1	C39	CAP., 4.7 $\mu$ F, X5R, 25V, 10%, 0603, AEC-Q200	MURATA, GRT188R61E475KE13D
12	1	C4	CAP., 2200pF, X7R, 50V, 10%, 0402, AEC-Q200	KEMET, C0402C222K5RACAUTO
13	1	C40	CAP., 2200pF, X7R, 2000V, 10%, 1808	AVX, 1808GC222KAT1A
14	1	C41	CAP., 0.01 $\mu$ F, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E103KA37D
15	1	C42	CAP., 100 $\mu$ F, ALUM. POLY. HYB., 25V, 20%, 6.3mm $\times$ 7.7mm, D8, RADIAL, AEC-Q200	PANASONIC, EEH2C1E101XP
16	1	C5	CAP., 0.022 $\mu$ F, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E223KA55D
17	1	C6	CAP., 1 $\mu$ F, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
18	2	C7, C8	CAP., 0.1 $\mu$ F, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C104KA55D
19	2	D1, D2	DIODE, SCHOTTKY, 100V, 250mA, SOD-323F, AEC-Q101	NEXPERIA, BAT46WJ,115
20	1	L1	IND., 1.5 $\mu$ H, PWR, SHIELDED, 20%, 12.2A, 11.9m $\Omega$ , 5.48mm $\times$ 5.28mm, AEC-Q200	COILCRAFT, XEL5030-152MEB
21	4	M1, M2, M3, M4	XSTR., MOSFET, N-CH, 40V, 40A, PG-TSDSON-8-32, AEC-Q101	INFINEON, IPZ40N04S5L-7R4
22	1	Q1	XSTR., MOSFET, P-CH, 30V, 36A, PowerDI5060-8, AEC-Q101	DIODES INC., DMP3010LPSQ-13
23	1	R1	RES., 0.005 $\Omega$ , 1%, 1.5W, 1206, LONG-SIDE TERM, KRL3216, METAL, SENSE, AEC-Q200	SUSUMU, KRL3216E-C-R005-F-T1
24	3	R2, R6, R35	RES., 100k, 5%, 1/16W, 0402, AEC-Q200	NIC, NRC04J104TRF
25	1	R23	RES., 49.9k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP4992F
26	1	R27	RES., 0.005 $\Omega$ , 1%, 1W, 0805, LONG-SIDE TERM., METAL, SENSE, AEC-Q200	SUSUMU, KRL2012E-M-R005-F-T1
27	2	R3, R29	RES., 59k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F5902TRF
28	1	R30	RES., 1M $\Omega$ , 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021M00JNED
29	1	R31	RES., 40.2k, 1%, 1/8W, 0805, AEC-Q200	PANASONIC, ERJ6ENF4022V
30	1	R32	RES., 698 $\Omega$ , 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCFO402FT698R
31	1	R34	RES., 6.04k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F6041TRF
32	1	R36	RES., 470 $\Omega$ , 5%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73B1ETTP471J
33	1	R4	RES., 30k, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCFO402FT30K0
34	1	R5	RES., 200k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP2003F

## PARTS LISTS

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
35	1	U1	IC, SYN. 4-SWITCH BUCK-BOOST CTRLR, QFN-28, AEC-Q200	ANALOG DEVICES, LT8253AJUFDM#WPBF
36	1	U2	IC, USB TYPE-C PORT CONTROLER, QFN-24, AEC-Q100	CYPRESS, CYPD3196-24LDXS

### Additional Demo Board Components

1	1	C9	CAP., 47 $\mu$ F, ALUM. ELECT., 50V, 20%, 6.3mm $\times$ 5.8mm SMD, RADIAL, AEC-Q200	PANASONIC, EEEFT1H470AP
2	1	C16	CAP., 10 $\mu$ F, X5R, 50V, 10%, 1206, AEC-Q200	MURATA, GRT31CR61H106KE01L
3	1	C17	CAP., 0.1 $\mu$ F, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H104KE02D
4	1	C18	CAP., 0.1 $\mu$ F, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E104KE02D
5	1	C20	CAP., 10 $\mu$ F, X7R, 25V, 10%, 1206, AEC-Q200	TAIYO YUDEN, TMK316AB7106KLHT
6	2	C44, C45	CAP., 1000pF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H102KA37D
7	1	D3	DIODE, ZENER, 18V, 300mW, SOD-523, AEC-Q101	DIODES INC., BZT52C18T-7
8	2	D4,D5	DIODE, SCHOTTKY, 20V, 1A, SOD-523, AEC-Q101	NEXPERIA, PMEG2010AEB,115
9	1	D6	LED, BLUE, WATERCLEAR, 0603	WURTH ELEKTRONIK, 150060BS75000
10	2	FB1, FB2	IND., 470 $\Omega$ AT 100MHz, FERRITE BEAD, 25%, 4A, 20m $\Omega$ , 1206, AEC-Q200	MURATA, BLM31KN471SZ1L
11	2	FB3, FB4	IND., 1k AT 100MHz, FERRITE BEAD, 25%, 1.5A, 150m $\Omega$ , 0805, AEC-Q200	TDK, MPZ2012S102ATD25
12	1	R10	RES., 2.2k, 1%, 1/16W, 0402, AEC-Q200	PANASONIC, ERJ2RKF2201X
13	2	R12, R14	RES., 2 $\Omega$ , 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022R00FKED
14	2	R13, R15	RES., 5.1 $\Omega$ , 5%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GEJ5R1X
15	2	R37, R38	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1002F
16	1	R7	RES., 200k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP2003F
17	0	R8	RES., OPTION, 0402	
18	3	R9, R22, R28	RES., 0 $\Omega$ , 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GE0R00X
19	2	RT1, RT2	RES., 100k, 1%, 1/10W, 0603, 4419K, NTC THERMISTOR, AEC-Q200	TDK, NTCG164KF104FTDS

### Hardware: For Demo Board Only

1	1	CN1	CONN., USB3.1, RCPT, 24POS, 1PORT, 0.5mm, R/A, HORZ, SMT, TYPE C	MOLEX, 1054500101
2	3	E1, E2, E3	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
3	1	J1	CONN., TERM. BLOCK, 1mm $\times$ 2.5mm, SIDE ENTRY, VERT, THT	MOLEX, 0395430602
4	1	J2	CONN., HDR, MALE, 1 $\times$ 5, 2.54mm, VERT, ST, THT	SAMTEC, TSW-105-07-L-S
5	1	JP1	CONN., HDR, MALE, 2 $\times$ 3, 2mm, VERT, STR, SMD	WURTH ELEKTRONIK, 62100621921
6	1	XJP1	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421





## 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.

## Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. **CONFIDENTIALITY.** This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. **ADDITIONAL RESTRICTIONS.** Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. **TERMINATION.** ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. **LIMITATION OF LIABILITY.** THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). **EXPORT.** Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. **GOVERNING LAW.** This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.