LTC4124/LTC4125, 100mA Wireless Li-Ion Charger Demonstration Kit

DESCRIPTION

DC2770A-B-KIT is a kit of the DC2773A-B transmitter board (featuring LTC®4125) and the DC2775A-D (featuring LTC®4124). The DC2775A-D receiver board can charge a single Li-Ion battery at up to 100 mA with an air gap of 3.0 mm to 5.0 mm between the transmit and receive coils.

The DC2773A-B transmitter supports Optimum Power Search and Foreign Object Detection features via LTC4125.

Design files for this circuit board are available.

CONTENTS

1 × DC2773A-B (LTC4125) Transmitter Demo Board

1 × DC2775A-D (LTC4124) Receiver Demo Board

PERFORMANCE SUMMARY

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	DC2773A-B Voltage Input	$I_{VIN} \leq 500mA$	4.5		5.5	V
I_{IN}	DC2773A-B V_{IN} Current	$V_{IN} = 5V$			500	mA
V_{BAT}	DC2775A-D Battery Charge Voltage	V_{SEL1} = HI, V_{SEL2} = HI		4.35		V
		V_{SEL1} = HI, V_{SEL2} = LO		4.20		V
		V_{SEL1} = LO, V_{SEL2} = HI		4.1		V
		V_{SEL1} = LO, V_{SEL2} = LO		4.00		V
I_{BAT}	DC2775A-D Charge Current	V_{BAT} = 4.0V, $I_{SEL1} = V_{CC}$, $I_{SEL2} = V_{CC}$		100		mA
AIR-GAP	Separation Between L_{TX} and L_{RX} Coils		3	3.5	5	mm
f_{TX_TANK}	DC2773A-B Resonant Tank Frequency			200		kHz
f_{RX_TANK}	DC2775A-D Resonant Tank Frequency			200		kHz

BOARD PHOTO

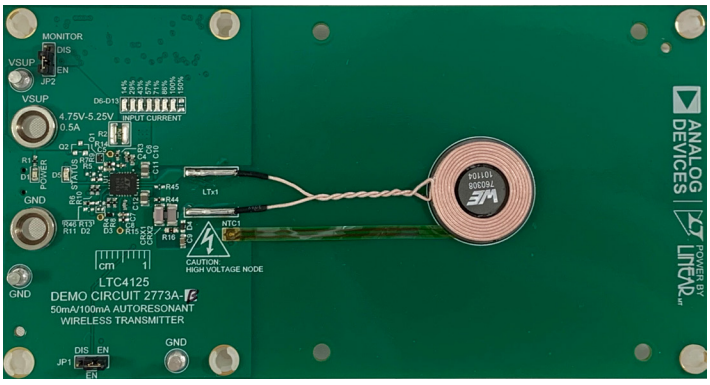


Figure 1. DC2773A-B Picture

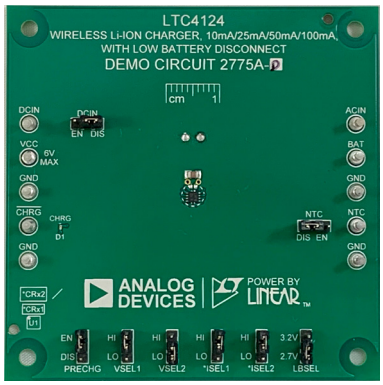


Figure 2. DC2775A-D Picture

QUICK START PROCEDURE

Refer to Figures 3, 4, and 5 for the proper measurement equipment setup, DC2775A-D mounting on DC2773A-B, and follow the procedure below:

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 signal and GND terminals. See Figure 6 for proper scope probe technique.

1. Place the DC2775A-D board atop the DC2773A-B board by aligning the mounting holes and screws on both boards. Make sure the air-gap between two coils is at about 3.5mm.
2. The default battery charge voltage is 4.2V and the charging current is 100mA. Battery charge voltage, charge current, pre-charge feature and low battery disconnect voltage can be programmed by jumpers on the DC2775A-D board.
3. Connect a voltage source PS1 and a 20 Ohm resistor RBAT1 between the BAT and GND turrets of DC2775A-D, respectively (Figure 4). PS1 and RBAT1 make up the battery emulator. Typical power supplies cannot sink current. By adding a resistor across the power supply inputs that draws more current than the maximum battery charging current, the power supply only sources current even when the battery charge current is at its maximum value.
4. Connect an ammeter AM1 between PS1 and the DC2775A-D BAT turret. Connect a voltage meter VM1 between DC2775A-D BAT and GND turrets.
5. Connect a power supply (PS2) between DC2773A-B V_{IN} turret and GND turret. DC2773A-B can also be powered through Micro-USB cable to a 5V power source.
6. Set PS1 = 3.7V, PS2 = 5V and enable both power supplies simultaneously. The DC2773A-B should start sweeping the LT_X current looking for a receiver. When a valid receiver is found, the LED sweeping will freeze until the next search period. This is also indicated by the DC2773A-B status green led being turned on. The input current monitor LED string will show the input current percentage with respect to 500mA current limit.
7. The DC2775A-D.D1 should be turned on, indicating power is delivered to the load. Observe AM1. AM1 should be reading 100mA of charge current into the battery emulator when the battery charger is in constant current mode. Compare VM1 voltage with battery charge voltage setting to make sure the battery charger is in constant current mode.
8. When test is done, turn off PS1 and PS2 simultaneously.

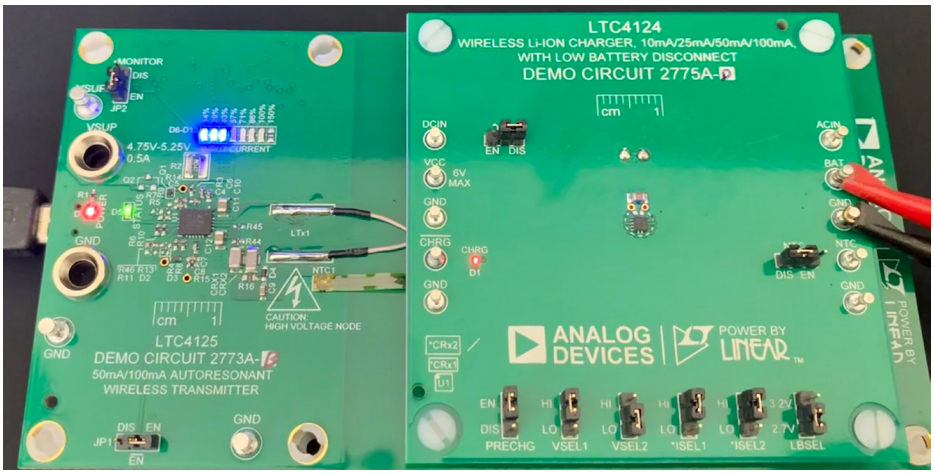


Figure 3. DC2770A-B-KIT in Operation

TEST SETUP

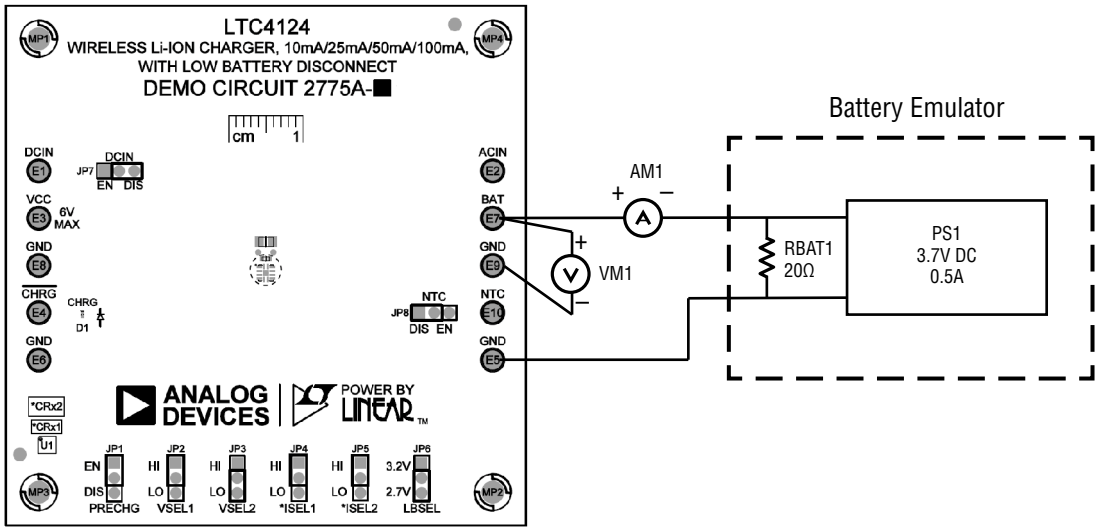


Figure 4. DC2775A-D Top

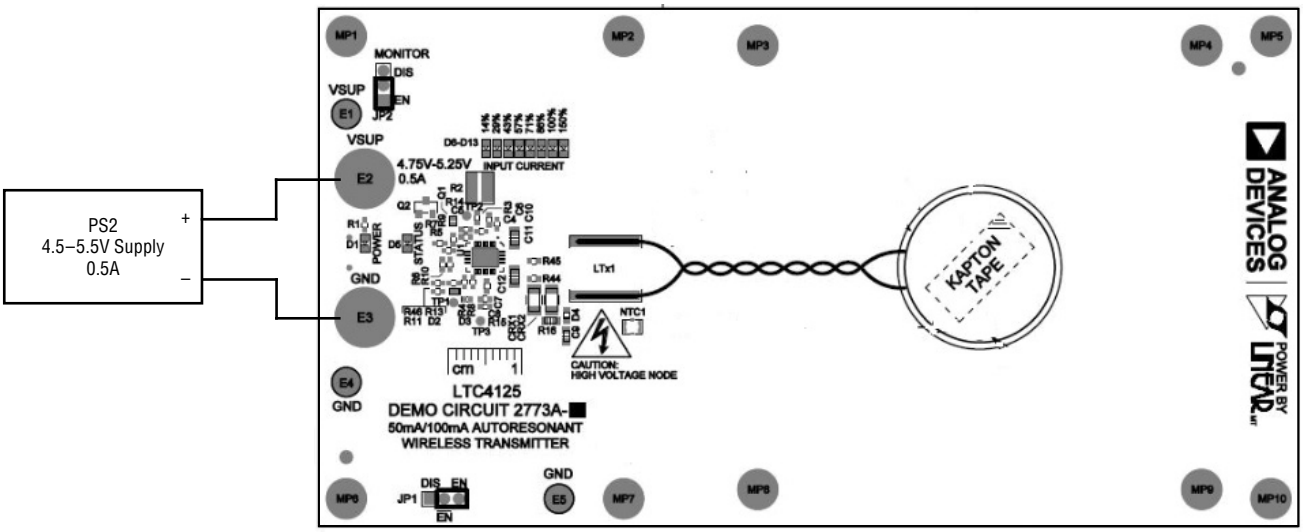


Figure 5. DC2773A-B Top

TEST SETUP

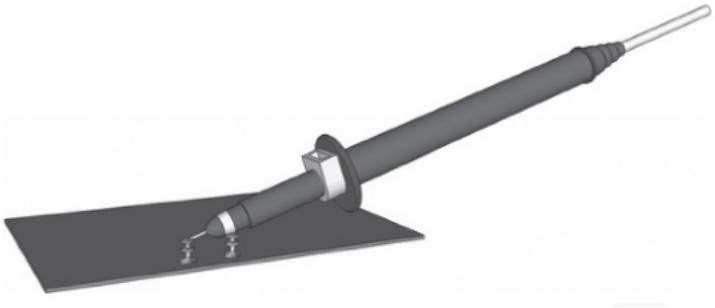


Figure 6. Measuring Input or Output Ripple

NOTE: All connections from equipment should be Kelvin connected directly to the board pins which they are connected on this diagram and any input or output leads should be twisted pair.

THEORY OF OPERATION

The DC2770A-B-KIT demonstrates operation of a magnetically coupled resonant Wireless Power Transfer (WPT) system. The LTC4125 transmitter provides efficient wireless power for the LTC4124 receiver to charge the Li-Ion battery.

DC2773A-B – Wireless Power Transmitter Board featuring the LTC4125

The LTC4125 implements an AutoResonant drive of the series resonant transmit tank composed of the transmit coil LT_X, and the transmit capacitor CT_X. The AutoResonant driver uses a zero-crossing detector to determine the resonant frequency of the tank. All sub-sequent duty cycles discussed here use the resonant period determined by the AutoResonant circuitry.

The SW1 and SW2 pins each have a half bridge driver. At zero current crossing, whichever SW_X pin has positive going current, is set to V_{IN} for a duty cycle determined by the corresponding PTH_X pin. When the SW_X pin is set to V_{IN}, it increases the current flowing in the transmitter resonant tank. The absolute value of the tank current is determined by the resonant tank components and also by the reflected load impedance.

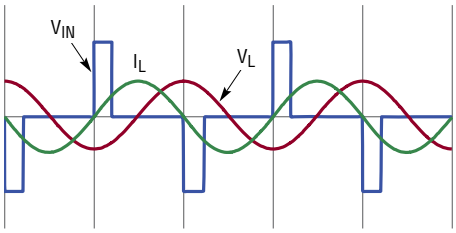


Figure 7. AutoResonant LC Tank Voltage and Current Waveforms with Square Wave Input at less than 50% Duty Cycle

The LTC4125 sweeps the duty cycle by way of a 5 bit DAC that sets the PTH_X voltage, and hence the duty cycle. The duration of each step of this DAC is programmable via CTS pin, which is set at 18ms in this demo.

The FB pin is driven by the node forming the junction of the transmit coil LT_X, and the transmit capacitor CT_X. The voltage at this node is proportional to the circulating current in the transmitter resonant tank.

The LTC4125 monitors the FB pin, and when a valid exit condition is found, it stops incrementing the PTH_X voltage. The PTH_X voltage is held at the detection level for the rest of the sweep cycle This sweep cycle timer is programmable by CTD pin, which is approximately 5 seconds in this demo.

If the receiver is removed from the transmitter, resonant tank current will rise significantly. The FB pin captures the rise of resonant current and terminates both half bridge drivers. As a result, the transmit power is reduced to standby mode.

If metal foreign objects are inserted between the transmit coil and the receive coil, the resonant frequency will increase significantly. The LTC4125 captures the rise of resonant frequency and reduces the transmit power to standby mode.

In standby mode, the LTC4125 will look for a valid receiver every 5s. If a valid receiver is found, the power transfer is resumed.

The LTC4125 uses an NTC resistor to monitor the temperature of the LT_X and shut off the transmit power if the NTC reports a temperature higher than approximately 42°C. Please see the applications section of the data sheet for more detailed information.

DC2775A-D – Wireless Power Receiver Board featuring the LTC4124

The DC2775A-D demo board implements a parallel resonant LC circuit that connects the LTC4124 between ACIN and GND pins. The AC waveform on the resonant circuit is rectified by the internal wireless power manager circuit to DC voltage on V_{CC} pin. This DC source is then fed into the internal linear battery charger to charge a Li-Ion battery.

As shown in Figure 8, when the LTC4124 receives more energy than it needs to charge the battery, the wireless power manager in the IC keeps the input voltage to the IC (at V_{CC} Pin) low by shunting the receiver resonant tank to ground. In this way, the linear charger is highly efficient as its input is always kept just above the battery voltage, V_{BAT}.

THEORY OF OPERATION

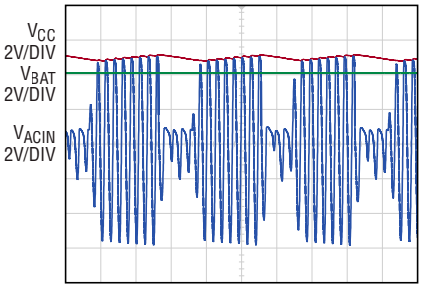


Figure 8. Rectification of AC Input and Regulation of V_{CC}

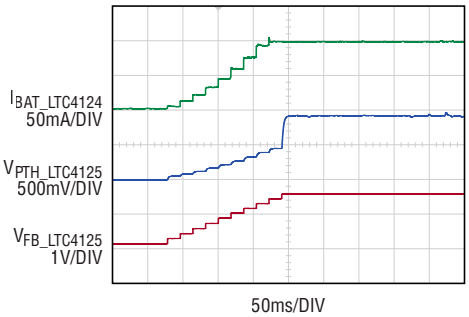


Figure 9. LTC4124 Shunting Event Triggering Exit Condition for LTC4125 to Stop the Search Algorithm

As shown in Figure 9, when paired with DC2773A-B, the LTC4124 shunting event triggers an exit condition for LTC4125 to stop its search algorithm. In this way, DC2773A-B always finds a transmit power level that is just enough for LTC4124 to charge the battery. This feature allows the receiver to be placed at various axial distance and misalignment while maintaining the same charge current. It also increases the efficiency at light load condition when the LTC4124 demands less power at the end of the charge cycle.

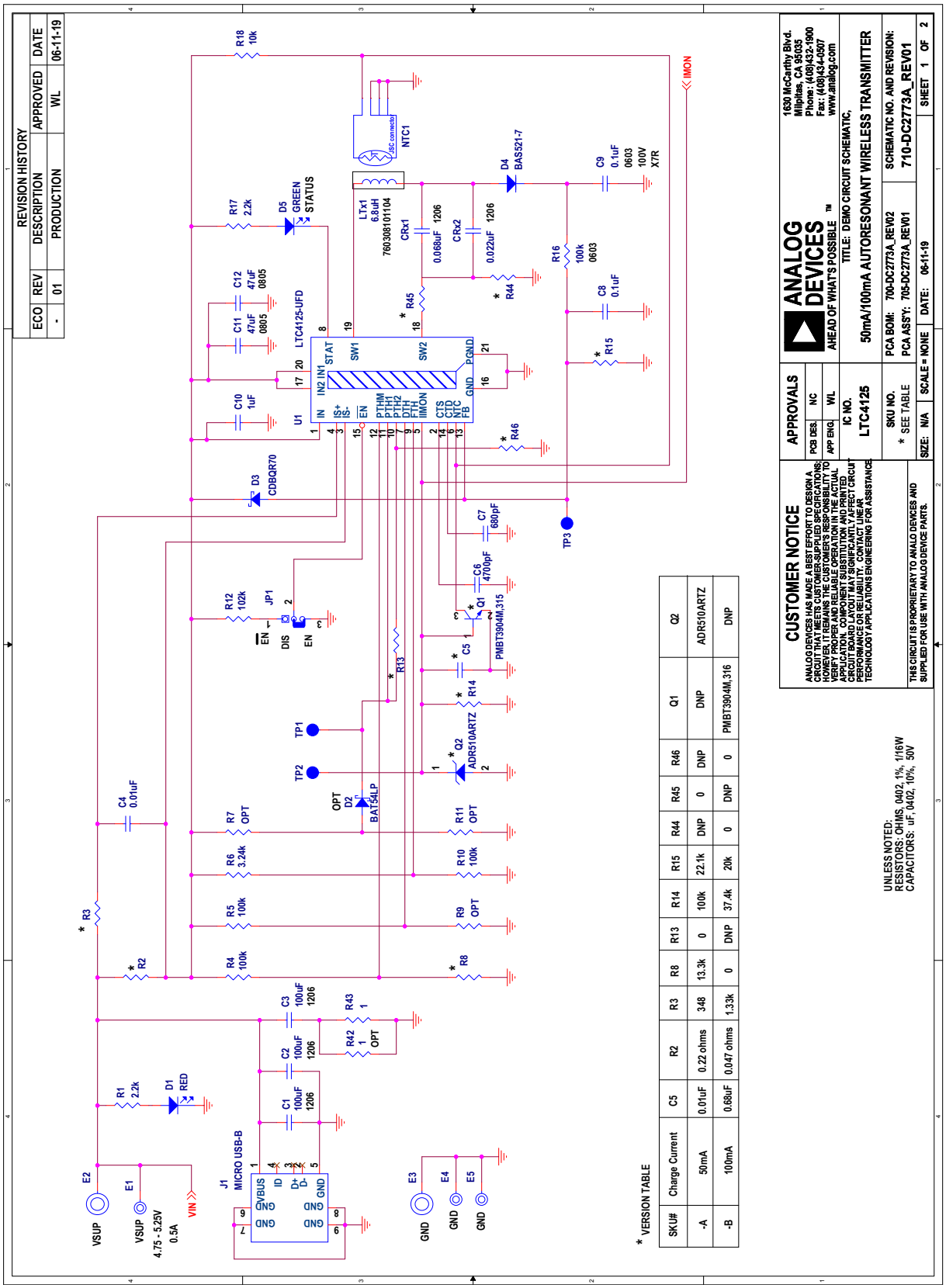
The LTC4124 includes a full featured CC/CV (Constant Current/Constant Voltage) linear battery charger with trickle current pre-charge, safety timer termination, bad battery detection, temperature qualified safe charging and automatic recharge. The maximum charge current supported by DC2775A-D is 100mA and the charge voltage is programmable by $VSEL_X$ jumpers.

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2773A-B: Required Circuit Components				
1	3	C1, C2, C3	CAP., 100uF, X5R, 6.3V, 10%, 1206	MURATA, GRM31CR60J107KE39L
2	1	C4	CAP., 0.01uF, X7R, 50V, 10%, 0402	KEMET, C0402C103K5RAC7867
3	1	C5	CAP., 0.68uF, X5R, 10V, 10%, 0402	YAGEO, CC0402KRX5R6BB684
4	1	C6	CAP., 4700pF, X7R, 50V, 10%, 0402	AVX, 04025C472KAT2A
5	1	C7	CAP., 680pF, C0G, 25V, 5%, 0402	KEMET, C0402C681J3GACTU
6	1	C8	CAP., 0.1uF, X7R, 50V, 10%, 0402	AVX, 04025C104KAT2A
7	1	C9	CAP., 0.1uF, X7R, 100V, 10%, 0603	AVX, 06031C104KAT2A
8	1	C10	CAP., 1uF, X5R, 16V, 10%, 0402	AVX, 0402YD105KAT2A
9	2	C11, C12	CAP., 47uF, X5R, 6.3V, 20%, 0805	SAMSUNG, CL21A476MQYNNNE
10	1	CRx1	CAP., 0.068uF, C0G, 50V, 5%, 1206, AEC-Q200	MURATA, GCM31C5C1H683JA16L
11	1	CRx2	CAP., 0.022uF, C0G, 50V, 5%, 1206, AEC-Q200	TDK, CGA5C2C0G1H223J060AA
12	1	D3	DIODE, SCHOTTKY, 70V, 70mA, 0402/SOD-923F	COMCHIP, CDBQR70
13	1	D4	DIODE, SWITCHING, 300V, 250mA, SOD-523	DIODES INC., BAS521-7
14	1	D5	LED, GREEN, WATER CLEAR, 0603	LITE-ON, LTST-C190KGKT
15	1	LTx1	IND., 6.8uH, WIRELESS CHRG. COIL, TX, 10%, 2.5A, 125mOHMS, 20.5mm Dia x 2.6mm H, 1 COIL, 1 LAYER	WURTH ELEKTRONIK, 760308101104
16	1	NTC1	RES., 10k OHMS, 1%, NTC THERMISTOR	MURATA, FTN55XH103FD4B
17	1	Q1	XSTR., NPN, 40V, 0.2A, SOT883, AEC-Q101	NEXPERIA, PMBT3904M, 315
18	2	R1, R17	RES., 2.2k OHMS, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022K20JNED
19	1	R2	RES., 0.047 OHMS, 1%, 1W, 0612, CURRENT SENSE	SUSUMU, PRL1632-R047-F-T1
20	1	R3	RES., 1.33k OHMS, 1%, 1/16W, 0402	VISHAY, CRCW04021K33FKED
21	2	R4, R5	RES., 100k OHMS, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
22	1	R6	RES., 3.24k OHMS, 1%, 1/10W, 0402	PANASONIC, ERJ2RKF3241X
23	1	R8	RES., 16.5K OHMS, 1%, 1/16W, 0402, THICK FILM, AEC-Q200	VISHAY, CRCW040216K5FKED
24	2	R10, R14	RES., 100k OHMS, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF1003X
25	1	R12	RES., 102k OHMS, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT102K
26	1	R14	RES., 37.4k OHMS, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT37K4
27	1	R15	RES., 20k OHMS, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF2002X
28	1	R16	RES., 100k OHMS, 1%, 1/10W, 0603, 350V, AEC-Q200	ROHM, KTR03EZPF1003
29	1	R18	RES., 10k OHMS, 5%, 1/16W, 0402	YAGEO, RC0402JR-0710KL
30	1	R43	RES., 1 OHM, 5%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3GEYJ1R0V
31	1	U1	IC, 5W Wireless Power Transmitter, QFN-20 (4x5), AutoResonant	ANALOG DEVICES, LTC4125EUFD#PBF
Additional Circuit Components				
1	3	C13, C15, C16	CAP., 0.01uF, X7R, 50V, 10%, 0402	KEMET, C0402C103K5RAC7867
2	2	C14, C17	CAP., 1uF, X5R, 16V, 10%, 0402	AVX, 0402YD105KAT2A
3	1	D1	LED, RED, WATER-CLEAR, 0603	LITE-ON, LTST-C193KRKT-5A
4	7	D6-D12	LED, BLUE, WATER CLEAR, 0603	LUMEX, SML-LXFP0603USBCTR
5	1	R41	RES., 2.2k OHMS, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022K20JNED
6	3	R8, R44, R46	RES., 0 OHM, 1/16W, 0402	NIC, NRC04Z0TRF

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
7	1	R19	RES., 10k OHMS, 5%, 1/16W, 0402	YAGEO, RC0402JR-0710KL
8	2	R20, R33	RES., 430 OHMS, 5%, 1/16W, 0402	YAGEO, RC0402JR-07430RL
9	1	R21	RES., 15.4k OHMS, 1%, 1/16W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1542F
10	1	R22	RES., 27.4k OHMS, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040227K4FKED
11	1	R23	RES., 511k OHMS, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402511KFKED
12	7	R24-R30	RES., 75k OHMS, 1%, 1/16W, 0402	VISHAY, CRCW040275K0FKED
13	1	R31	RES., 11.3k OHMS, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040211K3FKED
14	1	R32	RES., 787k OHMS, 1%, 1/16W, 0402	NIC, NRC04F7873TRF
15	7	R34-R40	RES., 6.2k OHMS, 1%, 1/16W, 0402	YAGEO, RC0402FR-076K2L
16	1	R45	RES., 0 OHM, 1/16W, 0402	ROHM, MCR01MZPJ000
17	2	U2, U3	IC, QUAD COMPARATOR LP 1.221VREF, DFN-16 (5x4)	ANALOG DEVICES, LTC1445CDHD#PBF
Hardware: For Demo Board Only				
1	3	E1, E4, E5	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THICK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	2	E2, E3	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
3	1	J1	CONN., MICRO USB-B, RCPT., FEMALE, 5-PIN, HORZ. R/A SMT	WURTH ELEKTRONIK, 629105136821
4	2	JP1, JP2	CONN., HDR., MALE, 1x3, 2mm, THT, STR, NO SUBS. ALLOWED	SAMTEC, TMM-103-02-L-S
5	6	MP1, MP2, MP5-MP7, MP10	STANDOFF, NYLON, SNAP-ON, 0.50"	WURTH ELEKTRONIK, 702935000
6	1	NTC ASSEMBLY_1	CONN., JSC COAXIAL SOCKET, RCPT., FEMALE, SMD, 1PORT, I/O TERM.	MURATA, MM5831-2700RB
7	2	XJP1, XJP3	CONN., SHUNT, FEMALE, 2 POS, 2mm	Wurth Elektronik, 60800213421
DC2775A-D: Required Circuit Components				
1	1	C3	CAP., 47uF, X5R, 6.3V, 20%, 0603	MURATA, GRM188R60J476ME15D
2	1	CRx2	CAP., 0.047uF, C0G, 25V, 5%, 0805	KEMET, C0805C473J3GACAUTO
4	1	LRx1	IND., 12.6uH, WIRELESS CHRG. COIL RX Qi, 10%, 1.1A, 340mOHMS, 17mm Dia x 0.8mm H, 1 COIL, 1 LAYER	WURTH ELEKTRONIK, 760308101220
5	1	R2	RES., 0 OHM, 5%, 1/16W, 0402	ROHM, MCR01MZPJ000
6	1	RT1	RES., 100k OHMS, 1%, 0201, NTC THERMISTOR	TDK, NTCG064EF104FTBX
Additional Circuit Components				
1	1	D1	LED, RED, WATER CLEAR, 0201	KINGBRIGHT, APG0603SEC-E-TT
Hardware: For Demo Board Only				
1	10	E1-E10	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THICK	MILL-MAX, 2308-2-00-80-00-00-07-0
2	8	JP1-JP8	CONN., HDR, MALE, 1x3, 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000311121
3	8	XJP1-XJP8	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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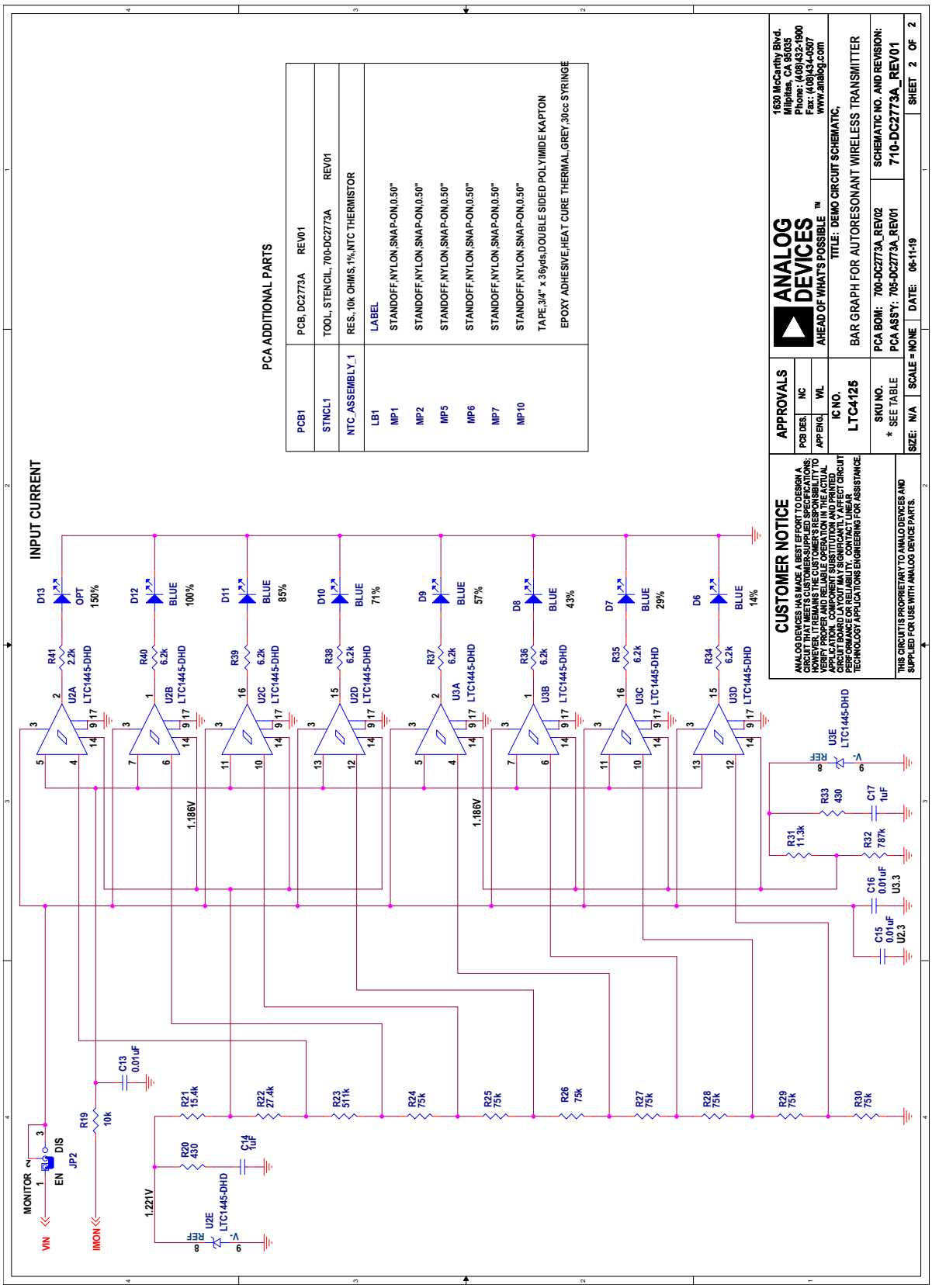
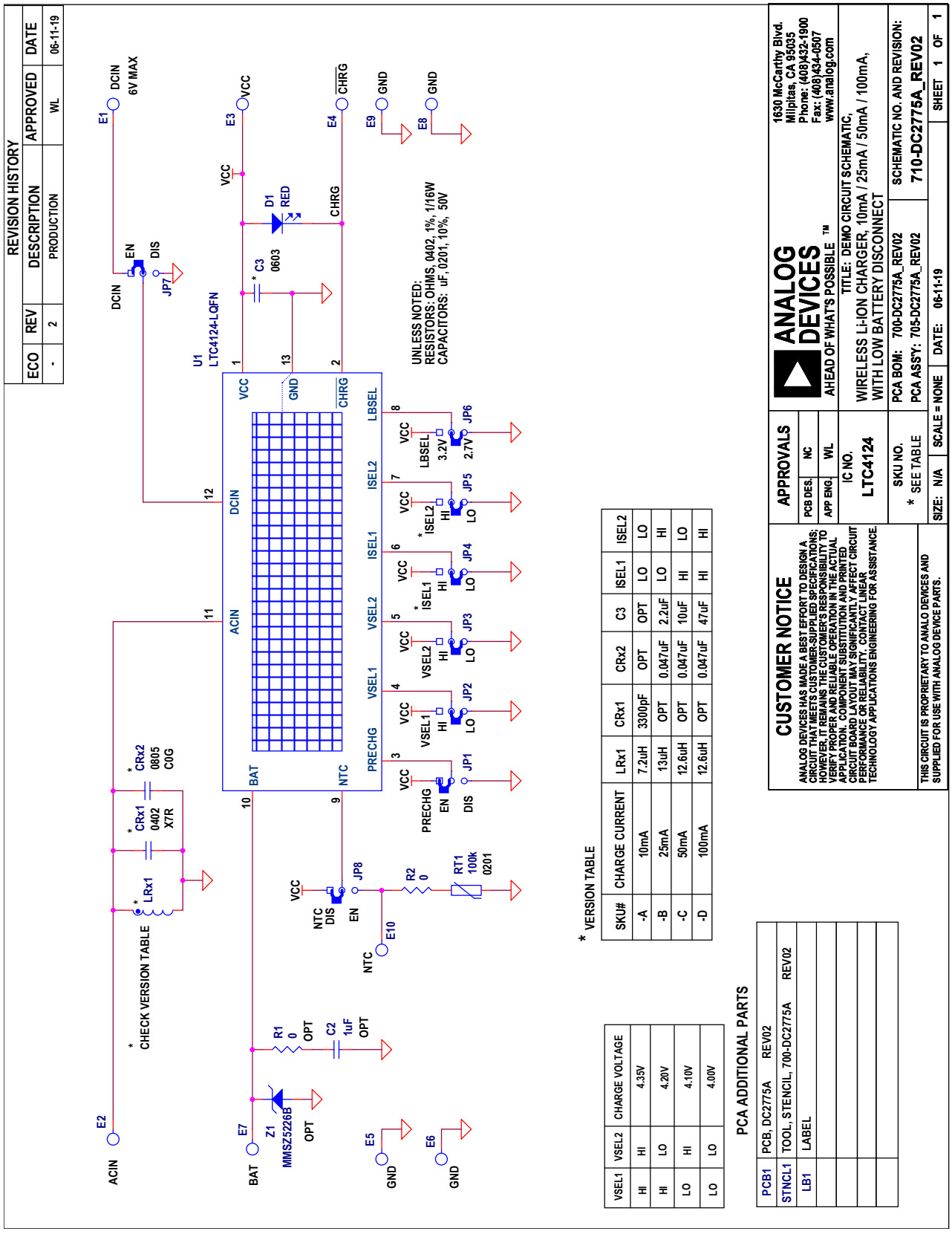


SCHEMATIC DIAGRAM



VSEL1	VSEL2	CHARGE VOLTAGE
HI	HI	4.35V
HI	LO	4.20V
LO	HI	4.10V
LO	LO	4.00V

SKU#	CHARGE CURRENT	LRx1	CRx1	CRx2	C3	ISEL1	ISEL2
-A	10mA	7.2uH	3300pF	OPT	OPT	LO	LO
-B	25mA	13uH	OPT	0.047uF	2.2uF	LO	HI
-C	50mA	12.6uH	OPT	0.047uF	10uF	HI	LO
-D	100mA	12.6uH	OPT	0.047uF	47uF	HI	HI

PCB1	PCB, DC2775A	REV02
STNCL1	TOOL, STENCIL, 700-DC2775A	REV02
LB1	LABEL	

Rev. 0

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.