

## LTC4124, 100mA Wireless Li-Ion Charger 100mA 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.](#)

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### 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	$I_{VIN} \leq 500\text{mA}$	4.5		5.5	V
$I_{IN}$	DC2773A-B $V_{IN}$ Current	$V_{IN} = 5\text{V}$			500	mA
$V_{BAT}$	DC2775A-D Battery Charge Voltage	$V_{SEL1} = \text{HI}, V_{SEL2} = \text{HI}$		4.35		V
		$V_{SEL1} = \text{HI}, V_{SEL2} = \text{LO}$		4.20		V
		$V_{SEL1} = \text{LO}, V_{SEL2} = \text{HI}$		4.1		V
		$V_{SEL1} = \text{LO}, V_{SEL2} = \text{LO}$		4.00		V
$I_{BAT}$	DC2775A-D Charge Current	$V_{BAT} = 4.0\text{V}, I_{SEL1} = V_{CC}, I_{SEL2} = V_{CC}$		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

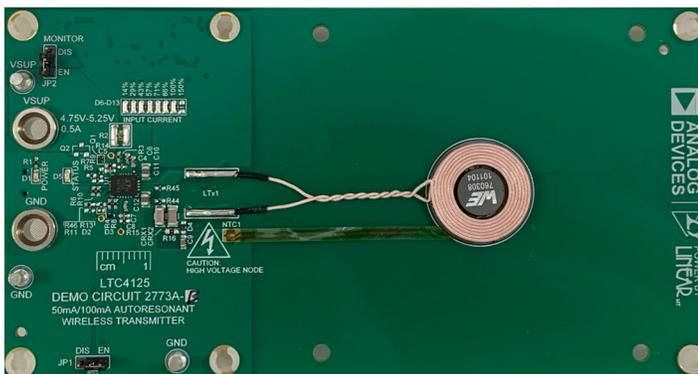


Figure 1. DC2773A-B Picture



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

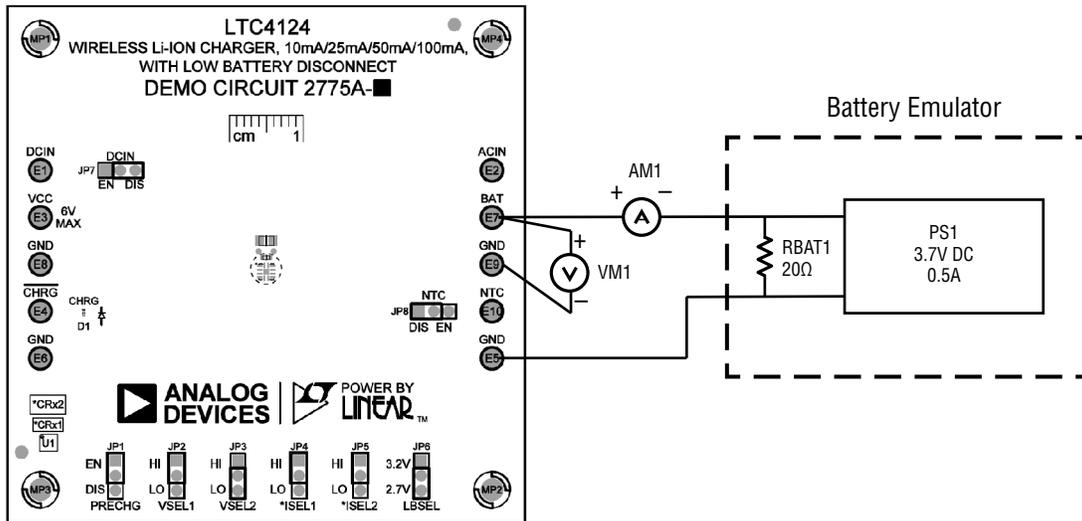


Figure 4. DC2775A-D Top

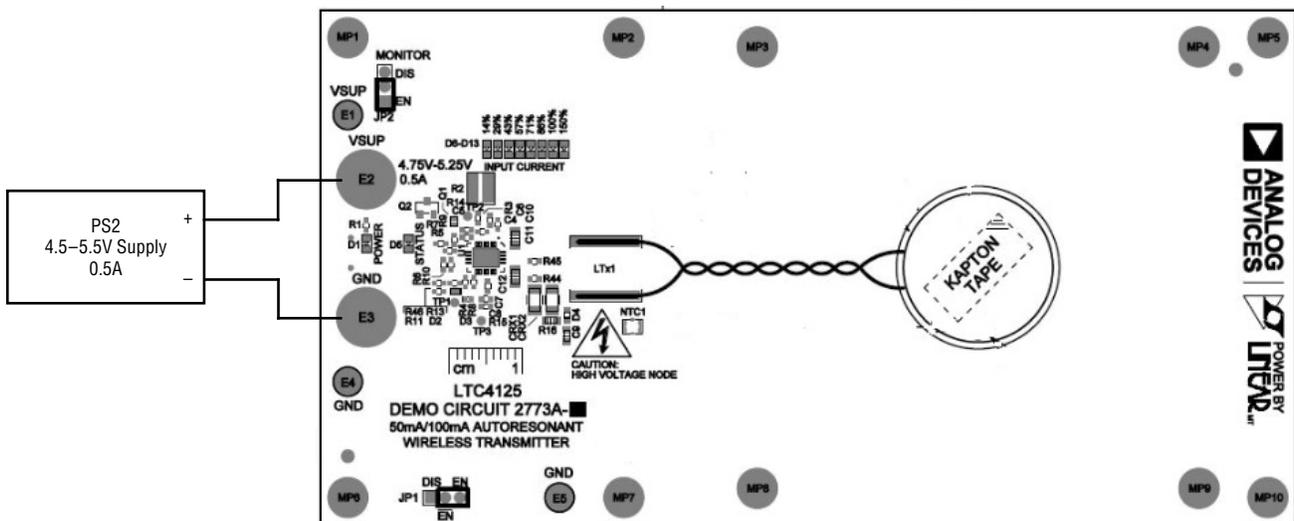
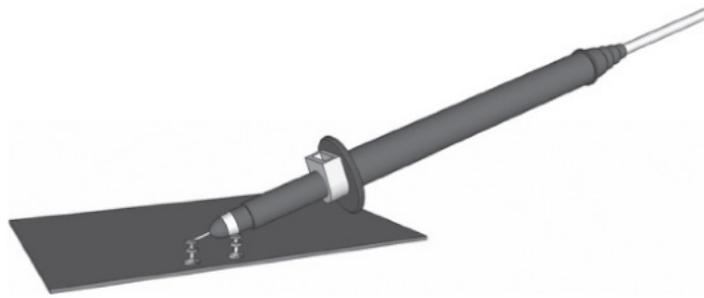


Figure 5. DC2773A-B Top

## 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.

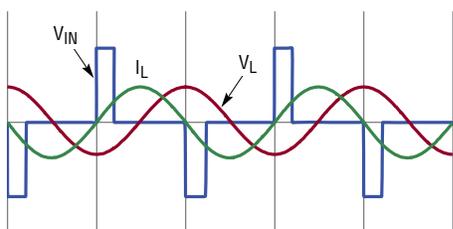
## THEORY OF OPERATION

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.

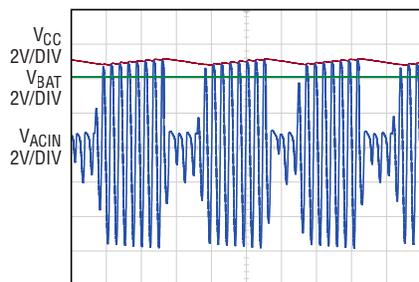
The LTC4125 uses an NTC resistor to monitor the temperature of the  $LT_X$  and shut off the transmit power if the NTC reports a temperature higher than approximately 42°C. Please see the applications section of the data sheet for more detailed information.

### 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.

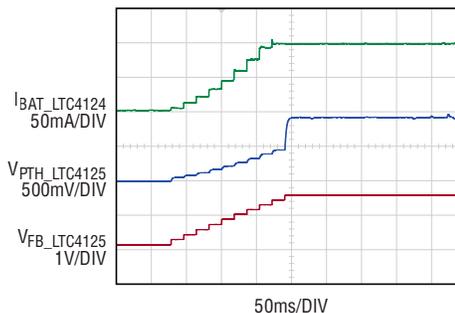
As shown in Figure 8, when the LTC4124 receives more energy than it needs to charge the battery, the wireless power manager in the IC keeps the input voltage to the IC (at  $V_{CC}$  Pin) low by shunting the receiver resonant tank to ground. In this way, the linear charger is highly efficient as its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

## THEORY OF OPERATION



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

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.



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

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.

# DEMO MANUAL DC2770A-B-KIT

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>DC2773A-B: Required Circuit Components</b>				
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 CHR. 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, RMCFO402FT102K
26	1	R14	RES, 37.4k OHMS, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC, RMCFO402FT37K4
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, LTC4125EUF#PBF
<b>Additional Circuit Components</b>				
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, NRC04ZOTRF

# DEMO MANUAL DC2770A-B-KIT

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, COG, 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

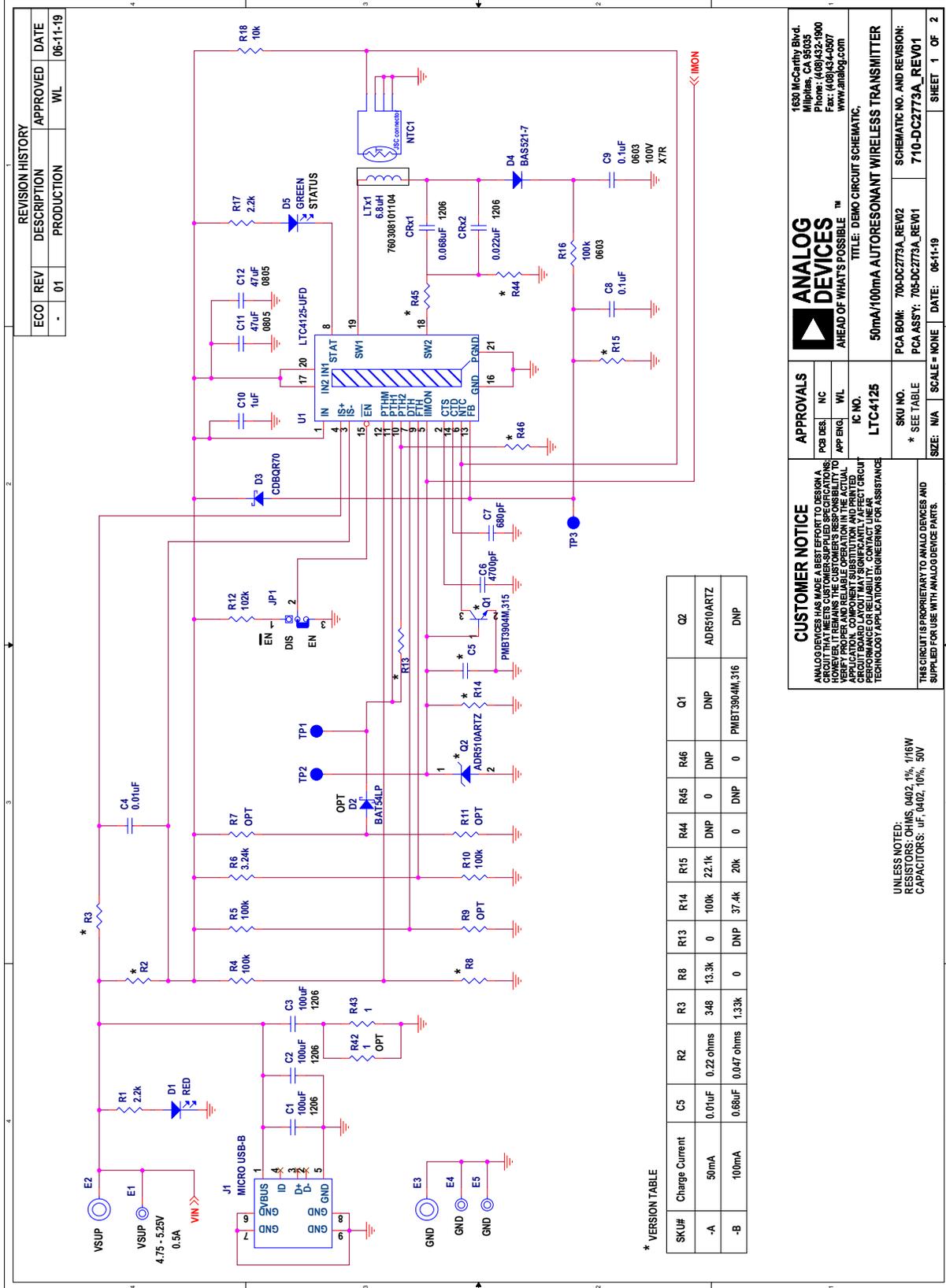
## Additional Circuit Components

1	1	D1	LED, RED, WATER CLEAR, 0201	KINGBRIGHT, APG0603SEC-E-TT
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## 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



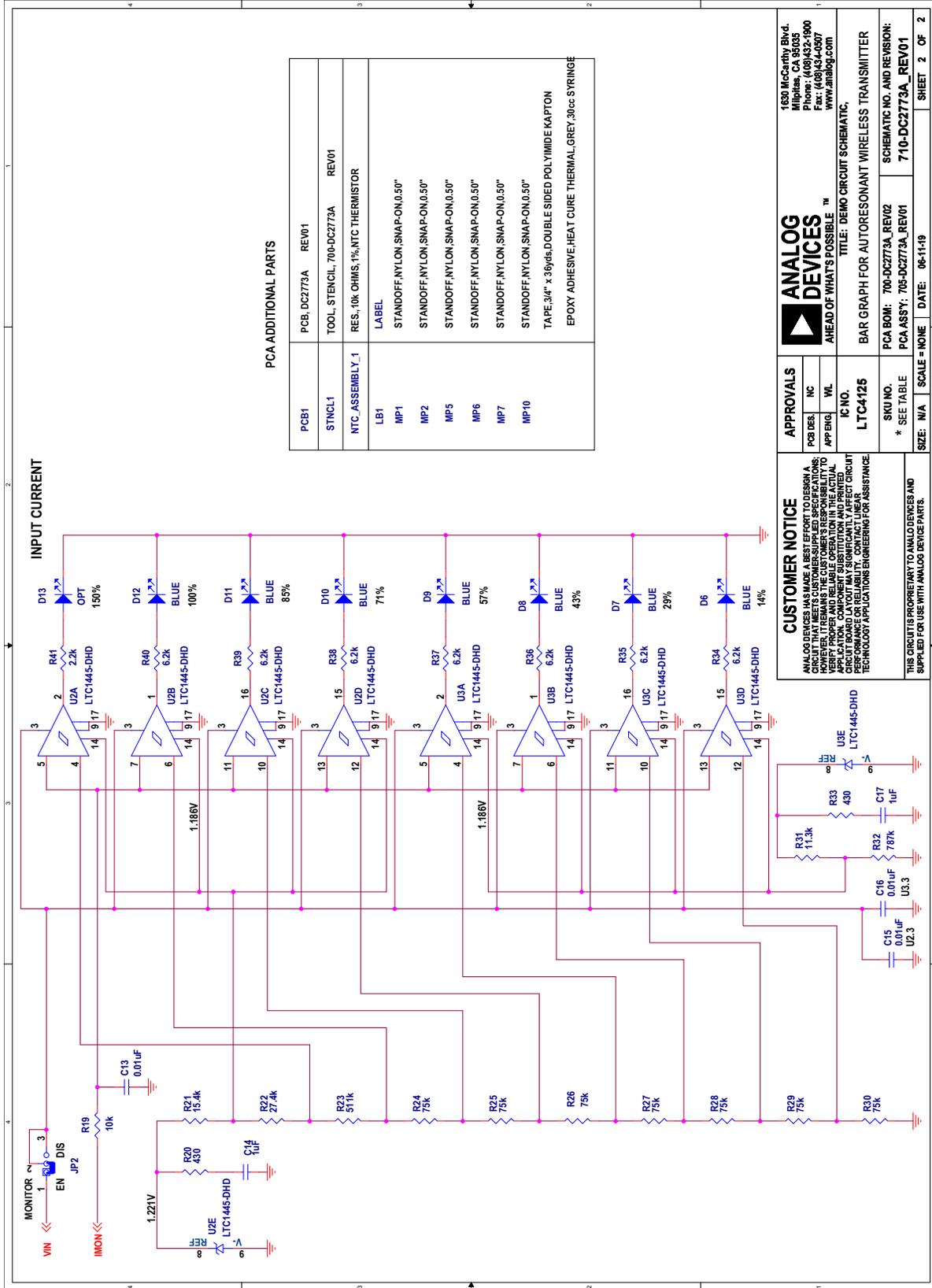
\* VERSION TABLE

SKU#	Charge Current	C5	R2	R3	R8	R13	R14	R15	R44	R45	R46	Q1	Q2
-A	50mA	0.01uF	0.22 ohms	348	13.3k	0	100k	22.1k	DNP	0	DNP	DNP	ADR510ARTZ
-B	100mA	0.68uF	0.047 ohms	1.33k	0	DNP	37.4k	20k	0	DNP	0	PMBT3904M,316	DNP

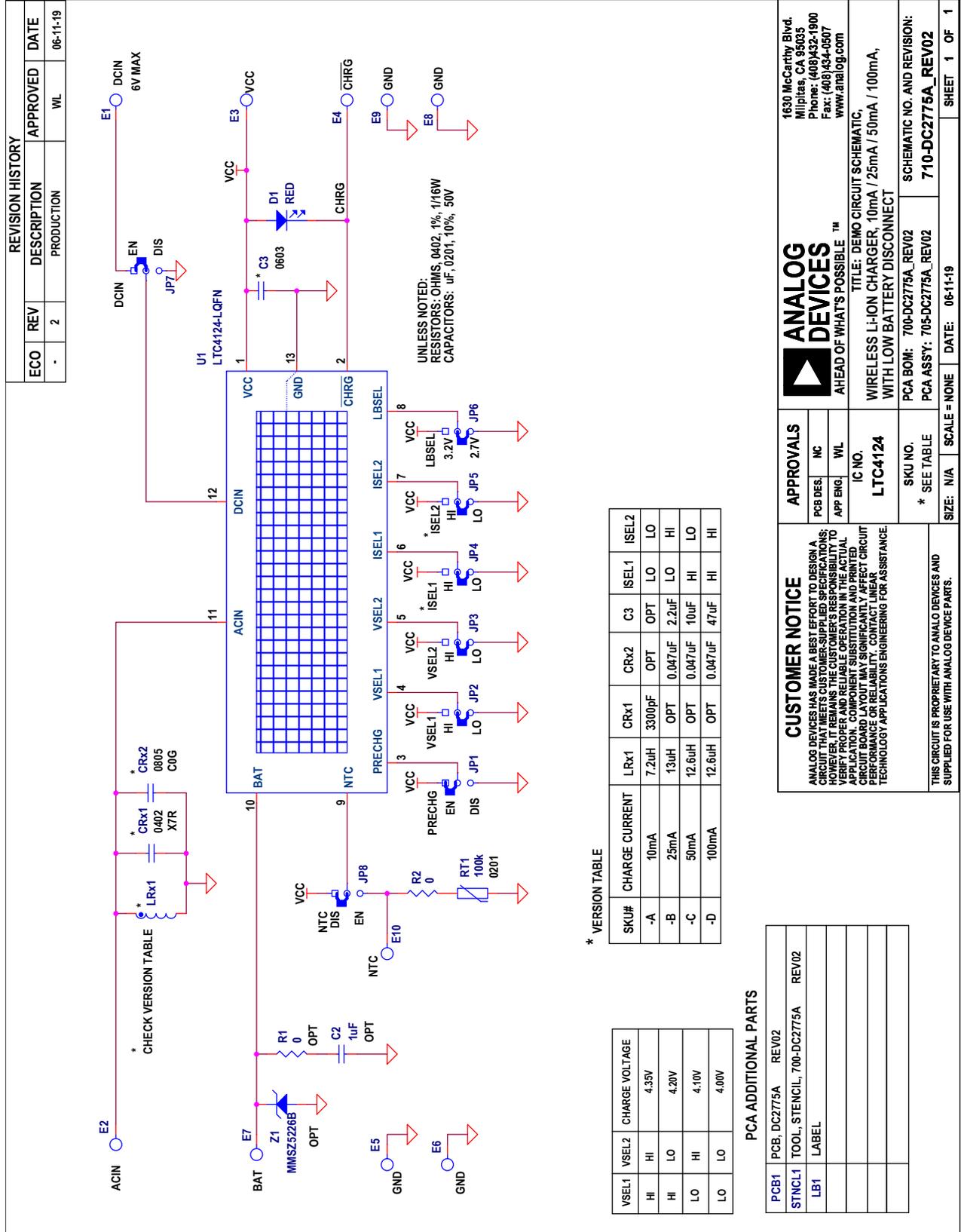


# DEMO MANUAL DC2770A-B-KIT

## SCHEMATIC DIAGRAM



**SCHEMATIC DIAGRAM**





## 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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