

# LT3967/LT3960

## 1.3A 8-Switch Matrix LED Dimmer with I<sup>2</sup>C to CAN-Physical Layer Transceiver

### DESCRIPTION

Demonstration circuit 2686A is a 1.3A 8-switch matrix LED dimmer system with an I<sup>2</sup>C to CAN-physical transceiver featuring the [LT<sup>®</sup>3967](#) and [LT3960](#). This demonstration circuit connects directly to a LED string and LED driver demonstration circuit to allow for independent dimming control of up to 8 channels of LEDs. A Linduino<sup>®</sup> One demonstration circuit is used to interface with the board and can connect in one of two different ways:

1. Connect directly to a Linduino One demonstration circuit with a QuikEval™ ribbon cable.
2. Connect using the LT3960 break-off board to connect to the I<sup>2</sup>C master device, but pass data over two twisted pair lines to the LT3960 on the main PCB.

The LT3967 matrix dimmer features 8 individually controlled 1.3A rated floating NMOS switch channels and can support up to 56V of LEDs per device. The channels of the LT3967 can be configured for series connections, or non-series connections. Additional DC2686A demo circuits can be connected in series for higher number of LEDs, or in parallel to allow for higher current operation. Resistors are used to configure both the I<sup>2</sup>C slave address as well as the default start-up state. The default configuration for DC2686A sets the I<sup>2</sup>C address as 0000 with all LEDs off. See the LT3967 data sheet for details.

The LT3960 I<sup>2</sup>C to CAN-Physical transceiver is used to send and receive I<sup>2</sup>C data through harsh or noisy environments at up to 400kb/s using the CAN-Physical layer for differential signaling over twisted pair connections. Both SDA and SCL data lines are converted to differential signals and are shared between devices connected to the bus. This allows for physical separation of the I<sup>2</sup>C source with the LT3960 transceiver board and the LT3967 main PCB along with the LED driver.

This demo circuit is designed to be easily configured and interfaced with a compatible low output capacitance LED driver and LED string. It can easily be directly attached to a buck LED driver or a floating buck-mode LED driver. More sophisticated setups with series matrix dimmers for higher number of LEDs such as 12 or 16 is possible. Please consult factory applications for details or look for more details on [analog.com](http://analog.com).

The LT3967 and LT3960 data sheets give complete description of the parts, their operation and applications information. The data sheets must be read in conjunction with this demo manual for demonstration circuit DC2686A. The LT3967EFE is assembled in a thermally enhanced 28-lead TSSOP package. The LT3960EMSE is assembled in a 10-lead MSOP package.

**[Design files for this circuit board are available.](#)**

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# DEMO MANUAL DC2686A

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

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage	LT3967, Operating	8		60	V
	LT3960, Operating	4.5	5	5.5	V
LED Voltage	LT3967, Operating			56	V
LED Current	LT3967, Operating			1.3	A
LT3967 ENH Threshold Falling Voltage ( $V_{IN} - \text{ENH}$ )	R1 = 10k, R2 = 49.9k	1.10	1.22	1.34	V
LT3960 EN/MODE Voltage	Master Mode	2		5	V
	Slave Mode	0.7		2	V
	Low-Power Shutdown Mode	0		0.7	V
Ext LDO Output Voltage	R22 = 392k, R23 = 127k		5		V
Ext CLK Frequency	R13 = 57.6k		350		kHz
LT3967 PWM Dimming Frequency	Ext CLK to RTSYNC		170		Hz
LT3967, LT3960 I <sup>2</sup> C CLK Frequency				400	kHz
LT3967 POR Initial Switch State	RADRR[4:1] = 0 $\Omega$		LED Off		

## QUICK START PROCEDURE

In order to properly function, DC2686A must be interfaced with a low output capacitance Buck LED driver or floating buck-mode LED driver. The input power supply to both LED driver and DC2686A must be set to at least 6V higher than each LT3967 SRC channel source voltage. This demo manual highlights interfacing DC2686A with a buck LED driver. For buck mode connections, refer to the LT3967 data sheet.

DC2686A works with a Linduino microcontroller board (DC2026C) and can be connected to a PC via USB. This allows DC2686A to be controlled via serial port interface in Arduino IDE. Refer to the [DC2026C](#) demo manual for detailed instructions on installing and configuring the necessary software and libraries.

1. Launch Arduino IDE.
2. Connect Linduino to computer via USB.
3. Download the Linduino code and library files from the DC2686A web page
4. Upload the code to the connected Linduino demo circuit.
5. With input power off, connect the input power supply from LED Driver to  $V_{IN}$  and GND of DC2686A.
6. Connect LED<sup>+</sup> and LED<sup>-</sup> from LED driver to DC2686A LED<sup>+</sup> and LED<sup>-</sup> terminals.
7. Connect 8 LEDs as shown in Figure 1 and Figure 2.
8. Connect Linduino to DC2686A using one of the two methods shown in Figure 1 and Figure 2.
9. Open up the serial monitor inside Arduino IDE.
10. Turn on input power supply.
11. Use command line interface in serial monitor to control and monitor LEDs.

**QUICK START PROCEDURE**

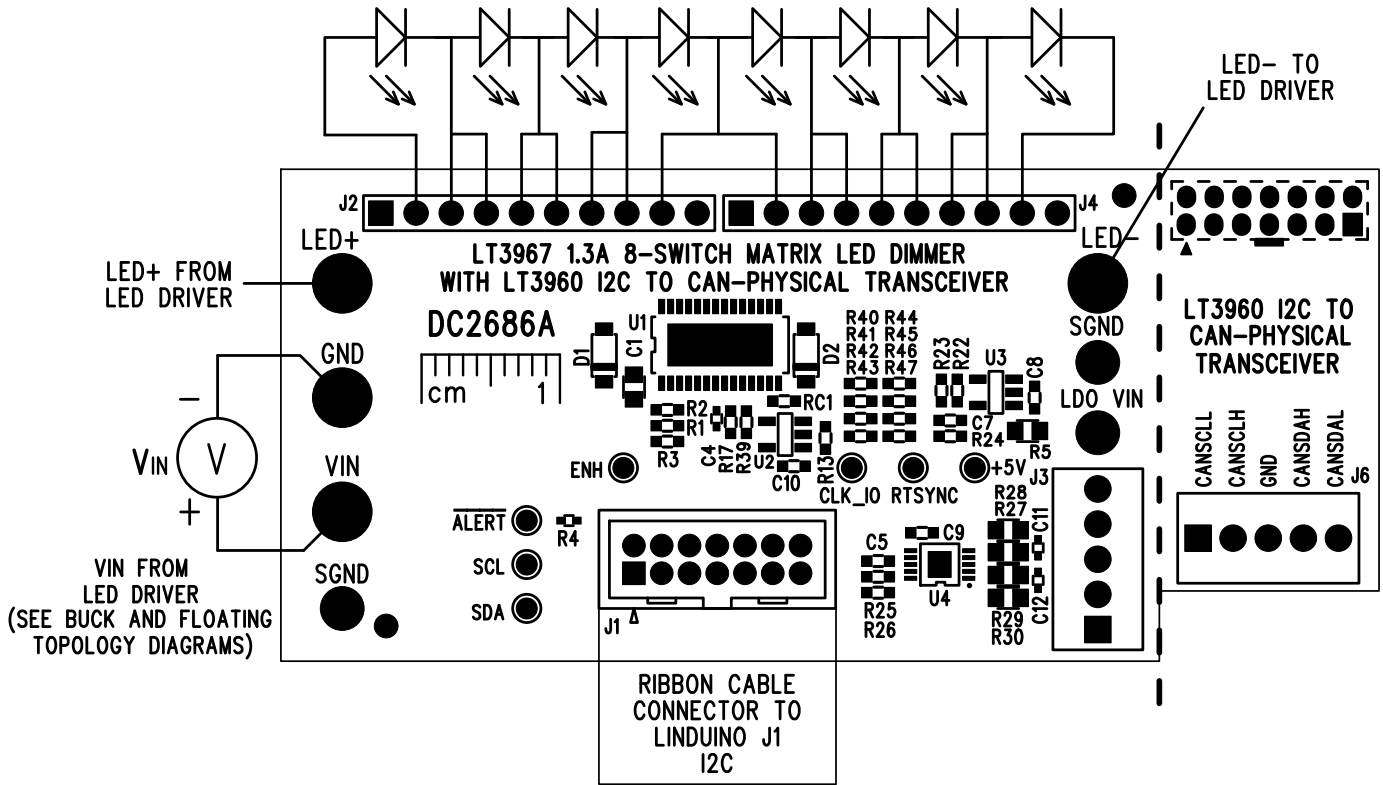


Figure 1. Quick-Start Procedure Setup Drawing for DC2686A (without LT3960)

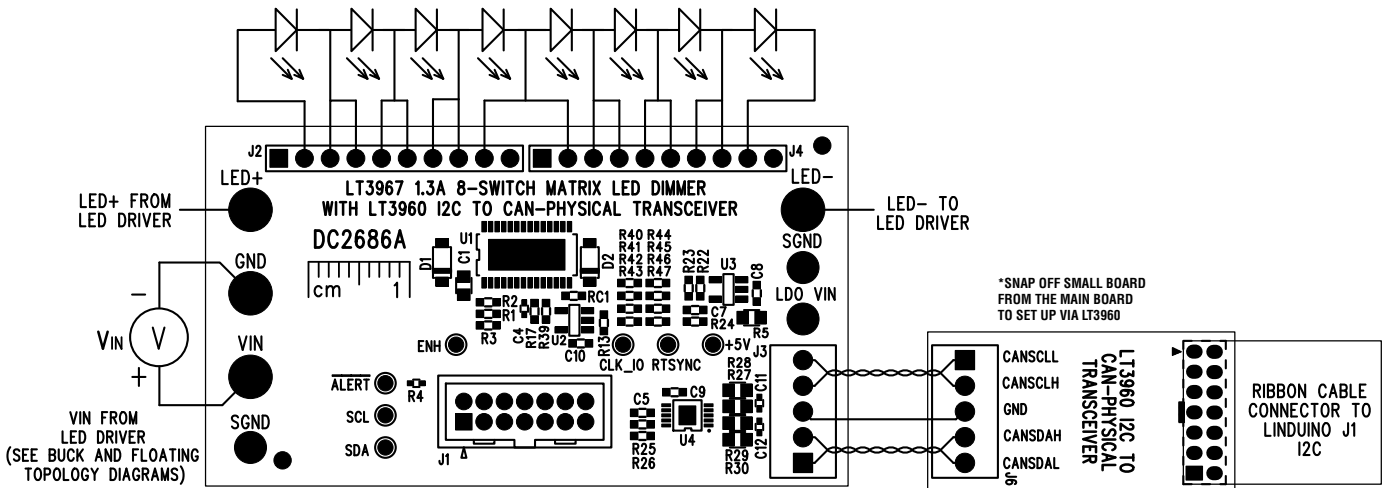


Figure 2. Quick Start Procedure Setup Drawing for DC2686A (with LT3960)

## BOARD OPTIONS

### SETUP DIFFERENCES BETWEEN BUCK VS BUCK-MODE

When using DC2686A with a buck LED driver, connect the  $V_{IN}$  of the buck LED driver directly to  $V_{IN}$  of LT3967, and ensure that  $V_{IN}$  is 6V higher than channel source voltages on the LT3967. When interfacing with a floating buck-mode LED driver, a charge pump is necessary to create the needed 6V headroom from  $V_{IN}$  to  $V_{SRC}$ . Please reference LT3967 data sheet for details on how to properly implement this.

### SETTING THE ADDRESS AND POR DEFAULT SWITCH STATE

Both the I<sup>2</sup>C address and power-on-reset (POR) default switch state are configured by placing resistors between the ADDR pins. Connecting the ADDR pins either  $V_{DD}$  or GND defines the unique I<sup>2</sup>C address. Using a resistor value less than 5k to set the address configures the LT3967 to start-up with the LEDs off, and using a resistor value greater than 50k configures the LEDs to be on. Refer to the LT3967 data sheet for detailed explanation on setting the default POR settings and I<sup>2</sup>C address.

### SETTING THE PWM DIMMING FREQUENCY

Dimming frequency for the LT3967 can be configured either by the internal oscillator or an external clock source. The LT3967's internal oscillator frequency is set by connecting a resistor from the RTSYNC pin to GND. Refer to the LT3967 data sheet for guidance on sizing this resistor for the desired dimming frequency.

An external clock source capable of sink 500 $\mu$ A at 0.4V can be used to override the internal oscillator. If either the internal oscillator or external clock source become slower than 100kHz, then the IC will switch to a 100kHz internal standby clock. The PWM dimming frequency is derived using clock division of the RTSYNC signal, diving down by 2048. DC2686A is equipped with an external clock source (LTC6900CS5) that can be powered from the 5V rail of either the onboard LDO or a connected Linduino.

### UTILIZING LT3960 FOR SERIAL COMMUNICATION

The LT3960 can be used to communicate with the LT3967 over longer distances and/or in noisy environments. DC2686A has two LT3960 ICs, one local to the LT3967 IC, and another on a snap-off board that plugs directly into the QuikEval header of the Linduino demo circuit (DC2026C).

The LT3960 on the snap-off board is powered by a Linduino when connected via QuikEval header. The EN/MODE pin is tied to the drain of a MOSFET that can be controlled by a Linduino. The MOSFET allows configuration of IC to be set to master mode, slave, or power off. The LT3960 on the main board can be powered by the on-board LDO. EN/MODE pin is not connected, configuring this device in slave mode. Twisted pair connections should be made between the differential pins of the LT3960 using the terminal blocks to connect.

### PROGRAMMING THE NUMBER OF CHANNELS

A single LT3967 can control up to 8 individual channels. For any unused channels, connect the associated DRN pins to  $V_{DD}$  with 100k resistor and the SRC pins to GND. This ensures proper fault monitoring for the unused channels.

LEDs can be driven in series by adding 0 $\Omega$  resistors to R6, R7, R10, R11, R12, R14, R15, which connects adjacent DRN and SRC channels at the J2 and J4 connectors. Channels can also be separated for individual LEDs control with non-serial LED string connections. DC2686A is configured for 8-channel operation but has resistor options that allow for easy reconfiguring to allow for as low as 6 LEDs. Solder a 0 $\Omega$  resistor to R16, R18, and 100k to R20, R21 to defeat the lower 2 channels of the LT3967.

### CONFIGURING THE ARDUINO COM TERMINAL

For operation of the command line interface, parameters of the terminal window must be set properly. 115200 Baud, No line ending, and Clear output should be selected. See Figure 3 for details.

## BOARD OPTIONS

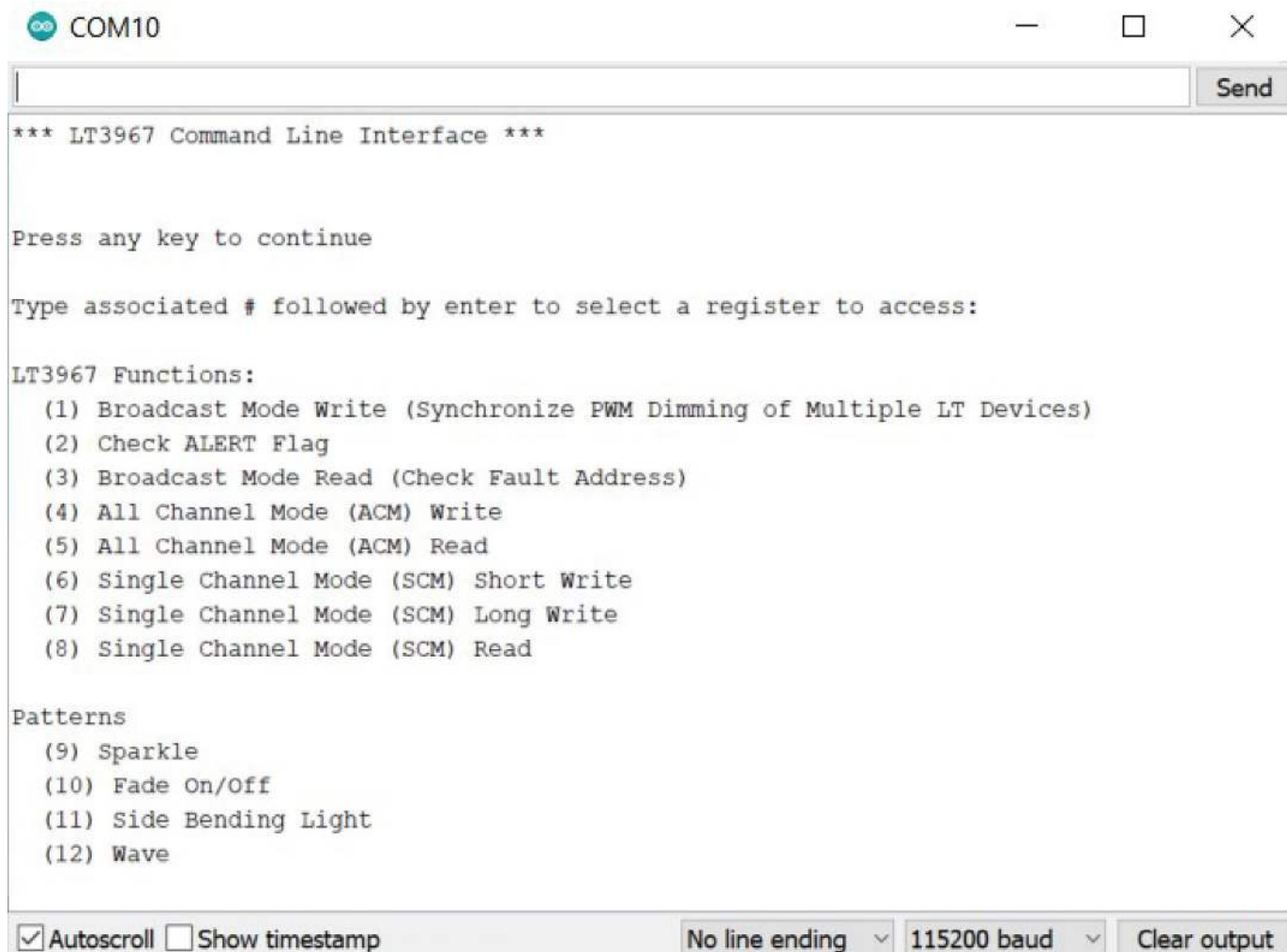


Figure 3. Arduino COM Terminal Window; Selectable Options Menu

## BOARD OPTIONS

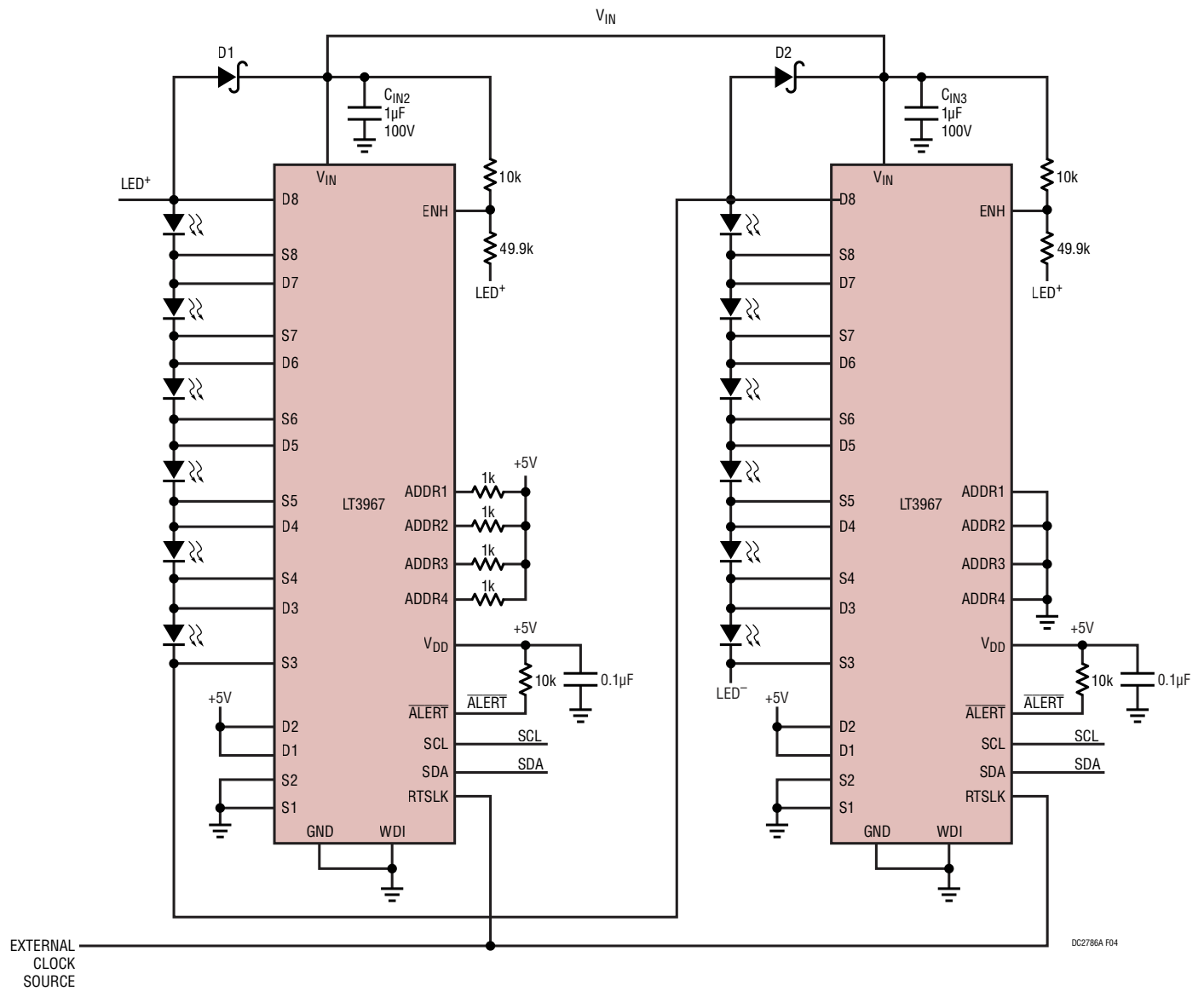


Figure 4. Two Series-Connected LT3967 ICs

**TEST RESULTS**

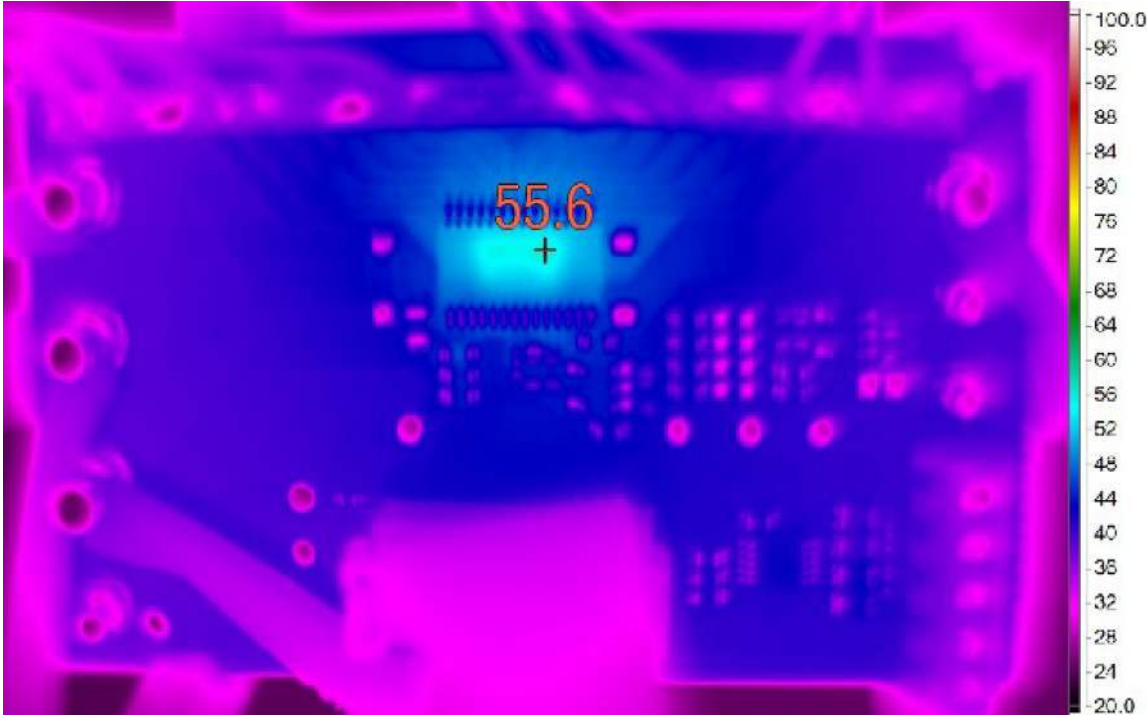


Figure 5. Thermal Capture of DC2686A at 50V<sub>IN</sub>, 8 Channels Shorted Through IC at 1.3A. LED<sup>+</sup> = 1.2V, LED<sup>-</sup> = 0V

# DEMO MANUAL DC2686A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Electrical Components for LT3967 Matrix Dimmer</b>				
1	1	C1	CAP., 1 $\mu$ F, X7S, 100V, 10%, 0805, AEC-Q200, NO SUBS. ALLOWED	MURATA, GCM21BC72A105KE36L
2	1	C4	CAP., 0.1 $\mu$ F, X7R, 10V, 10%, 0402, AEC-Q200	MURATA, GCM155R71A104KA55D
3	1	D1	DIODE, SCHOTTKY, 60V, 1A, SOD-123F, AEC-Q101	NEXPERIA, PMEG6010CEH, 115
4	1	R1	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310K0FKEA
5	1	R2	RES., 49.9k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF4992V
6	1	U1	IC, 8-SWITCH MATRIX LED DIMMER, TSSOP-28, 1.3A	ANALOG DEVICES., LT3967EFE#PBF
<b>Optional Electrical Components for LT3967 Matrix Dimmer</b>				
7	1	C5	CAP., 0.1 $\mu$ F, X7R, 16V, 10%, 0603, AEC-Q200	MURATA, GCM188R71C104KA37D
8	6	RC1, R3, R40, R41, R42, R43	RES., 0 $\Omega$ , 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
9	1	R4	RES., 10k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210K0FKED
10	0	R6, R7, R10, R11, R12, R14, R15, R16, R18, R19, R20, R21, R44, R45, R46, R47	RES., OPTION, 0603	
11	1	R13	RES., 57.6k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF5762V
12	1	R17	RES., 121k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603121KFKEA
13	1	R39	RES., 22k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060322K0FKEA
14	1	U2	OSCILLATOR, 1kHz to 20MHz, 5k AND/OR 10pF, $\pm$ 40ppm, TSOT23-5, RESISTOR SET OSC.	ANALOG DEVICES, LTC6900CS5#PBF
<b>Required Electrical Components for LT3960 I<sup>2</sup>C CAN</b>				
15	2	C9, C15	CAP., 2.2 $\mu$ F, X7S, 10V, 10%, 0603, AEC-Q200	TDK, CGA3E3X7S1A225K080AB
16	2	C10, C13	CAP., 1 $\mu$ F, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
17	4	C11, C12, C14, C16	CAP., 4700pF, X7R, 25V, 10%, 0402, AEC-Q200	YAGEO, AC0402KRX7R8BB472
18	1	Q1	XSTR., MOSFET, N-CH, 60V, 210mA, SOT-23, AEC-Q101	DIODES INC.2N7002Q-7-F
19	4	R25, R26, R33, R34	RES., 4.99k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06034K99FKEA
20	8	R27, R28, R29, R30, R31, R32, R35, R36	RES., 60.4 $\Omega$ , 1%, 1/8W, 0805, AEC-Q200	VISHAY, CRCW080560R4FKEA
21	1	R38	RES., 1k, 5%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031K00JNEA
22	2	U4, U5	IC, 12C TO DUAL CAN TRANSCEIVER, MSOP-10	ANALOG DEVICES, LT3960EMSE#PBF
<b>Optional Electrical Components for LT3960 I<sup>2</sup>C CAN</b>				
23	1	R37	RES., 0 $\Omega$ , 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EB
<b>Components for Optional 5V Source</b>				
24	1	C7	CAP., 0.47 $\mu$ F, X7R, 16V, 10%, 0603, AEC-Q200	MURATA, GCM188R71C474KA55D
25	1	C8	CAP., 1 $\mu$ F, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
26	0	R5	RES., OPTION, 0805	
27	1	R22	RES., 392k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603392KFKEA
28	1	R23	RES., 127k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603127KFKEA
29	1	R24	RES., 0 $\Omega$ , 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
30	1	U3	IC, LDO MICROPOWER LINEAR REG., SOT23-5, 20mA, 3V TO 80V	ANALOG DEVICES, LT3014IS5#PBF

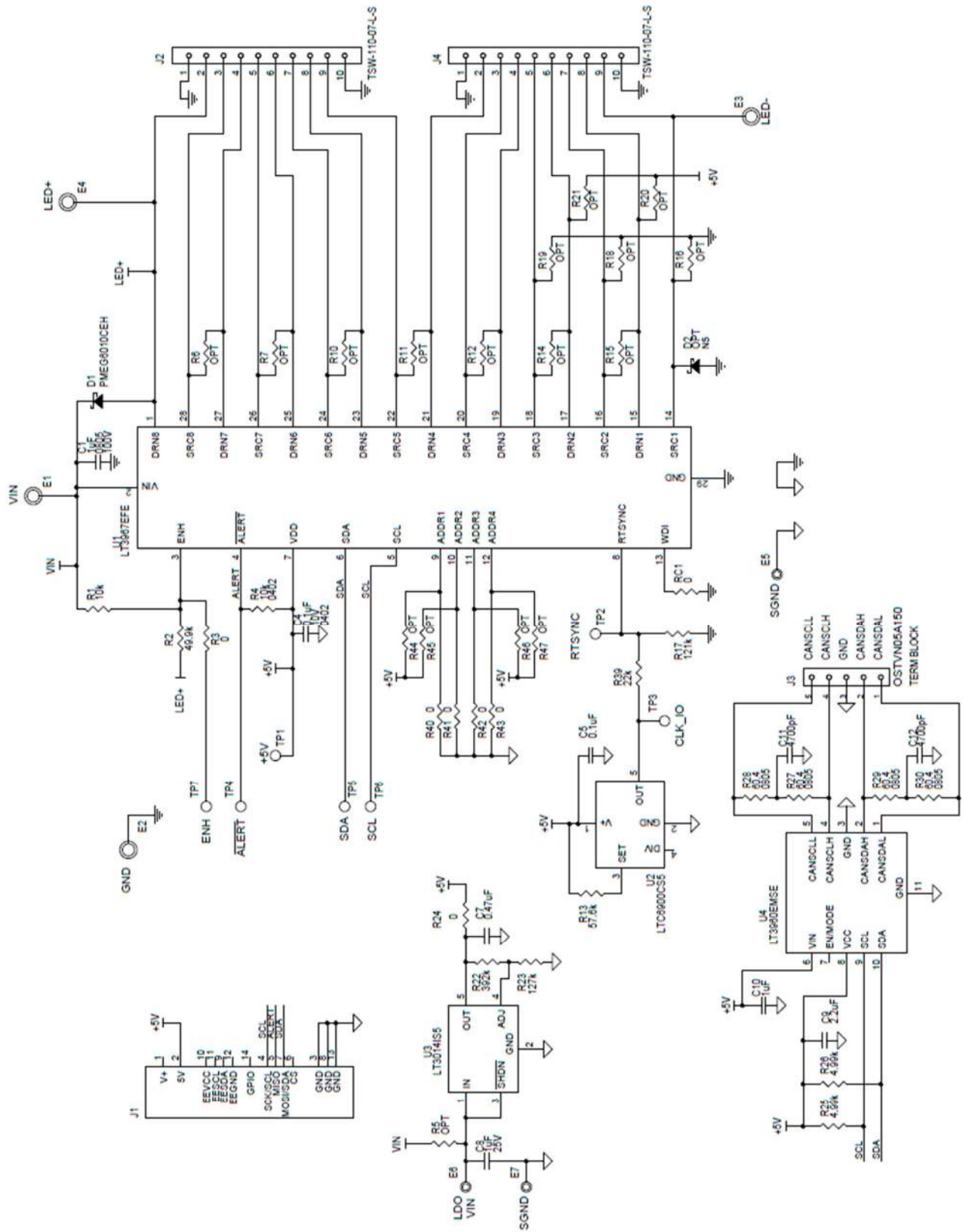


## PARTS LIST

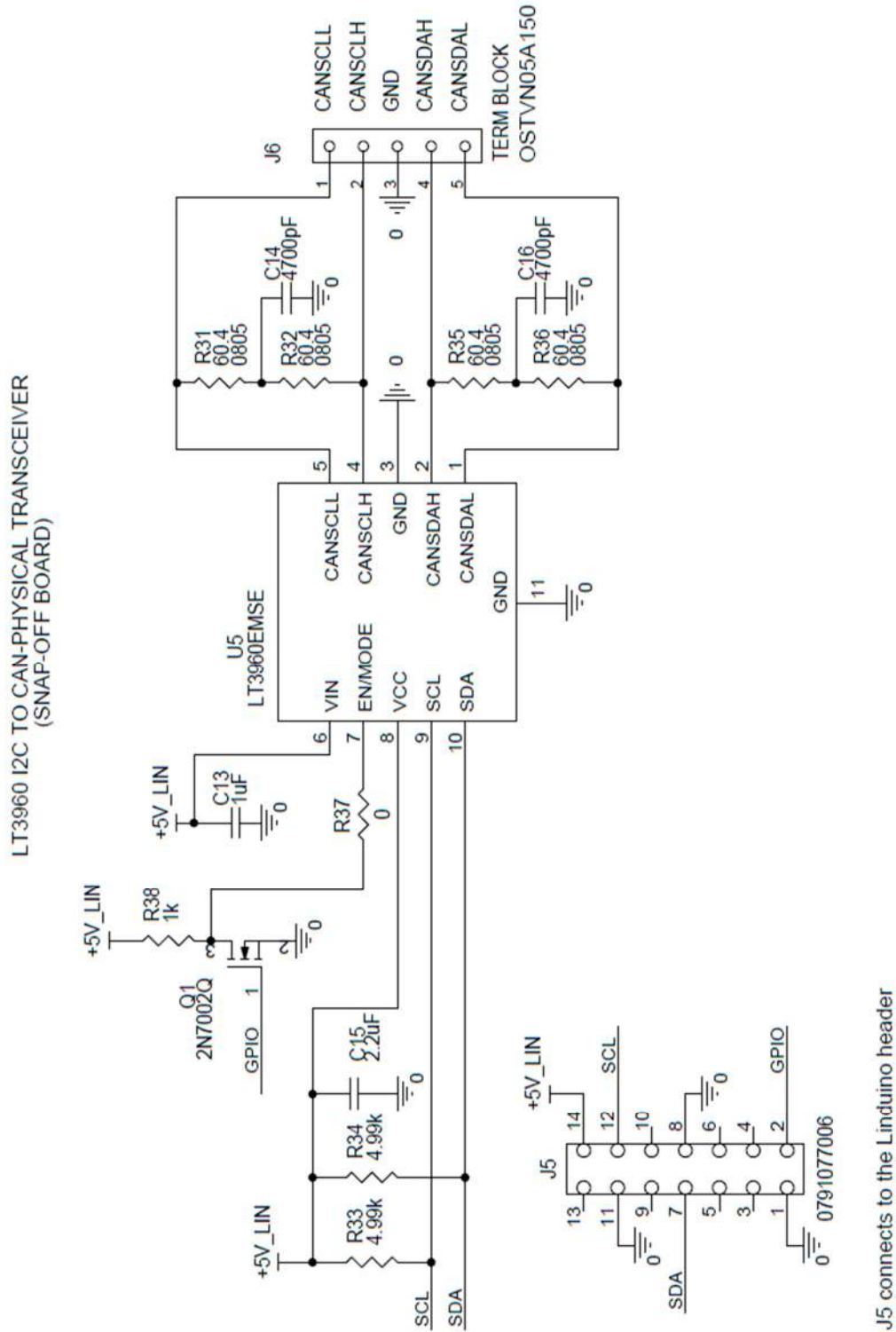
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Hardware</b>				
31	4	E1, E2, E3, E4	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
32	3	E5, E6, E7	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
33	1	J1	CONN., HDR, SHROUDED, MALE, 2x7, 2mm, VERT, ST, THT	MOLEX, 87831-1420
34	2	J2, J4	CONN., HDR, MALE, 1x10, 2.54mm, VERT, ST, THT	SAMTEC, TSW-110-07-L-S
35	2	J3, J6	CONN., TERM BLOCK, 5 POS, 2.54mm, ST, THT, SIDE ENTRY, GREEN	ON-SHORE TECHNOLOGY, OSTVN05A150
36	1	J5	CONN., SOCKET STRIP, RCPT, FEMALE, 2x7, 2mm, VERT, ST, THT	MOLEX, 0791077006

# DEMO MANUAL DC2686A

## 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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