

LT3094 –20V, 500mA, Ultralow Noise, Ultrahigh PSRR Negative Linear Regulator

DESCRIPTION

Demonstration circuit 2624A features the [LT[®]3094](#), an ultralow noise, ultrahigh power supply rejection ratio (PSRR) negative low dropout (LDO) regulator. DC2624A operates over an input range of –3.8V to –20V, and can deliver up to 500mA output current. It features ultralow noise (0.8 μ V_{RMS} from 10Hz to 100kHz) and very high PSRR (75dB at 1MHz).

The LT3094 enable function (EN/UVLO pin) is bidirectional and can be controlled with either a positive or a negative voltage. The LT3094 also offers programmable current limit functionality by connecting a resistor from I_{LIM} to GND. Current monitoring is also achieved by sensing the I_{LIM} pin voltage. The V_{IOC} tracking function controls an upstream switching converter to maintain a constant voltage across the regulator and, hence, minimize power dissipation. The power good feedback (PGFB) pin is used to set a programmable power good threshold, and activates

the fast start-up circuitry. To use the power good function, connect an external voltage source at V_{EXT}. If power good and fast start-up functionality are not needed, tie PGFB to IN.

Built-in protection includes reverse battery protection, reverse current protection, internal current limit with fold-back, and thermal limit with hysteresis.

The LT3094 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 demonstration circuit DC2624A. The LT3094 is assembled in 12-lead MSOP and 3mm × 3mm DFN packages with an exposed pad on the bottom-side of the IC. Proper board layout is essential for maximum thermal performance.

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

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

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range (V _{IN})	I _{OUT} = 150mA, V _{OUT} = –3.3V	–20		–3.8	V
Input Voltage Range (V _{IN})	I _{OUT} = 500mA, V _{OUT} = –3.3V	–7*		–3.8	V
Output Voltage (V _{OUT})	V _{IN} = –5V, I _{OUT} = 500mA	–3.39	–3.32	–3.25	V
Shutdown Input Current (I _{IN})	V _{EN} = 0V, V _{IN} = –5V		5		μ A

*The maximum input voltage for 500mA load current is set by the 60°C temperature rise of LT3094 on the demo circuit. Higher input voltages can be applied if a larger copper area and/or forced-air cooling is applied. The output current is also limited by the differential of input and output voltage. Please refer to the data sheet for details.

DEMO MANUAL DC2624A

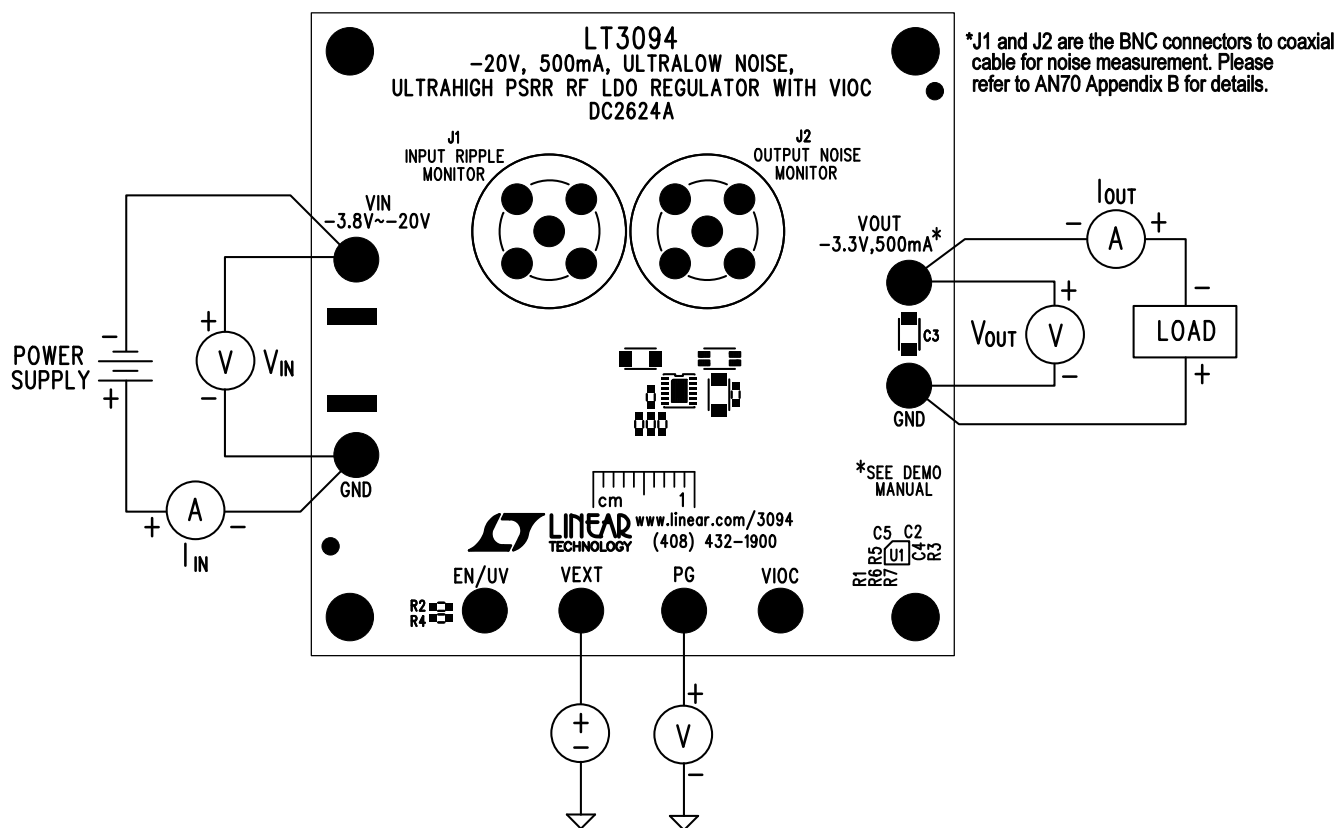
QUICK START PROCEDURE

Demonstration circuit 2624A is easy to set up to evaluate the performance of the LT3094EDD. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Connect a load between the V_{OUT} and GND terminals.
2. With power off, connect the input power supply to the V_{IN} and GND terminals.
3. Apply $-3.8V$ across V_{IN} to GND. The output voltage should be $-3.32V \pm 3\%$ ($-3.39V$ to $-3.25V$).
4. Vary V_{IN} from $-3.8V$ to $-20V$ and vary the load current from $0mA$ to $500mA$.

Note: Make sure the power dissipation is below the thermal limit.

5. Apply a power source at V_{EXT} . The PG pin voltage should be approximately equal to V_{EXT} .
6. Refer to Application Notes AN70 and AN159 for measuring output noise and PSRR.



*The maximum output current will be limited by internal current limit based on differential voltage of input and output voltage. Please refer to the datasheet.

Figure 1. Test Procedure Setup Drawing for DC2624A

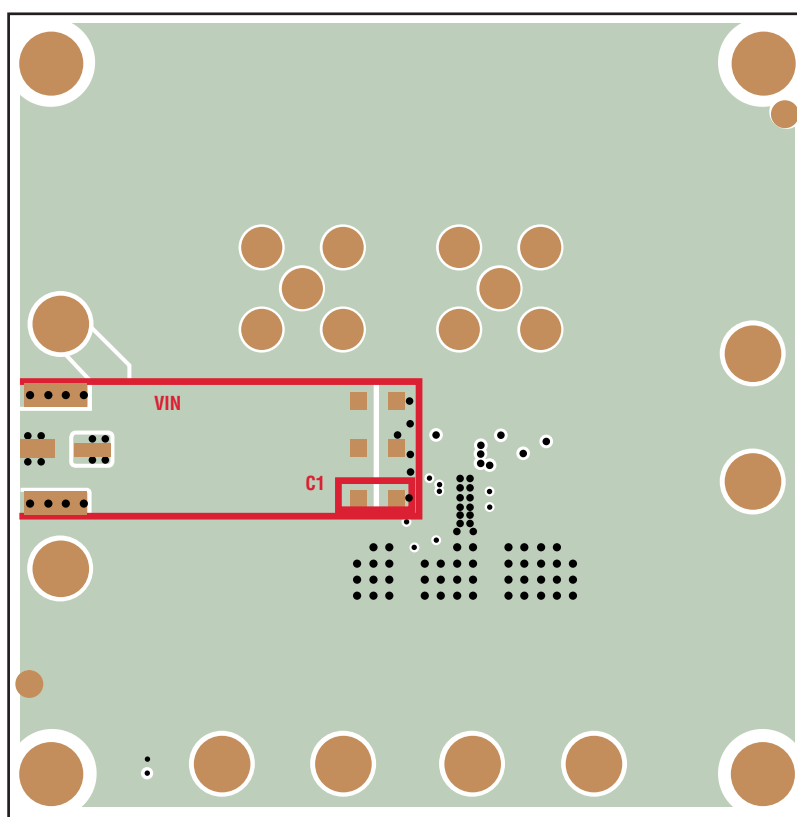
PCB LAYOUT

Best PSRR Performance: PCB Layout for Input Trace

For applications utilizing the LT3094 for post-regulating switching converters, placing a capacitor directly at the LT3094 input results in AC current (at the switching frequency) flowing near the LT3094. Without careful attention to PCB layout, this relatively high frequency switching current generates an electromagnetic field (EMF) that couples to the LT3094 output, thereby degrading its effective PSRR. Highly dependent on the PCB, the switching preregulator, and the input capacitor size, among other factors, the PSRR degradation can easily be 30dB at 1MHz. This

degradation is present even if the LT3094 is desoldered from the board, because it effectively degrades the PSRR of the PC board itself. While negligible for conventional low PSRR LDOs, LT3094's ultrahigh PSRR requires careful attention to higher order parasitics in order to realize the full performance offered by the regulator.

The LT3094 demo board alleviates this degradation in PSRR by using a specialized layout technique. In Figure 2, the input trace (V_{IN}) is highlighted in red together with input capacitor C1, and in Figure 3 the return path (GND) is also highlighted. Normally when



DC2624a F02

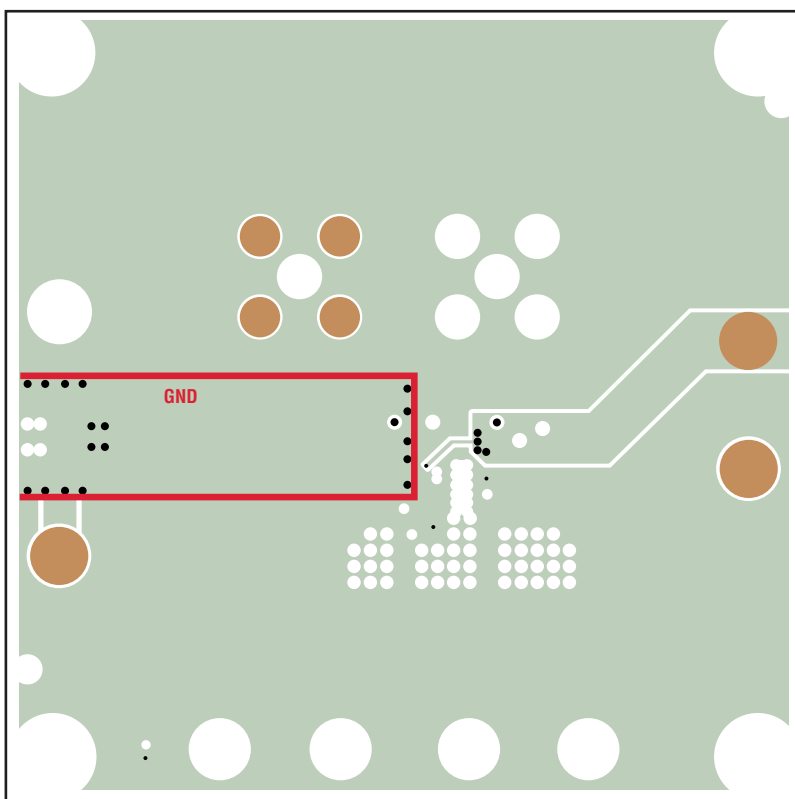
Figure 2. Bottom Layer of DC2624A

PCB LAYOUT

an AC voltage is applied to the input of the board, AC current flows on this path, thus generating EMF. This EMF couples to output capacitor C2 and related traces, making the PSRR appear worse than it actually is. *With the input trace directly above the return path, the EMFs are in opposite directions, and consequently cancel each other out. Making sure these traces exactly overlap each other maximizes the cancellation effect and thus provides the maximum PSRR offered by the regulator.*

Best AC Performance: PCB Layout for Output Capacitors C2

For ultrahigh PSRR performance, the LT3094 bandwidth is quite high (~1MHz), making it very close to the output capacitor's self-resonance frequency (~1.6MHz). Therefore, it is very important to avoid adding extra impedance (ESL & ESR) outside the feedback loop. To that end, minimize the effects of PCB trace and solder inductance by Kelvin connecting OUTS and SET pin capacitor GND directly to output capacitors (C2) terminals using split capacitor techniques as shown in Figure 4 and Figure 5. With only small AC current flowing through these connections, the impact of solder joint/PCB trace inductance on stability is eliminated. While the LT3094 is robust enough not to oscillate if the recommended layout is not followed, phase/gain margin and stability will degrade.



DC2624a F03

Figure 3. Layer 3 of DC2624A

PCB LAYOUT

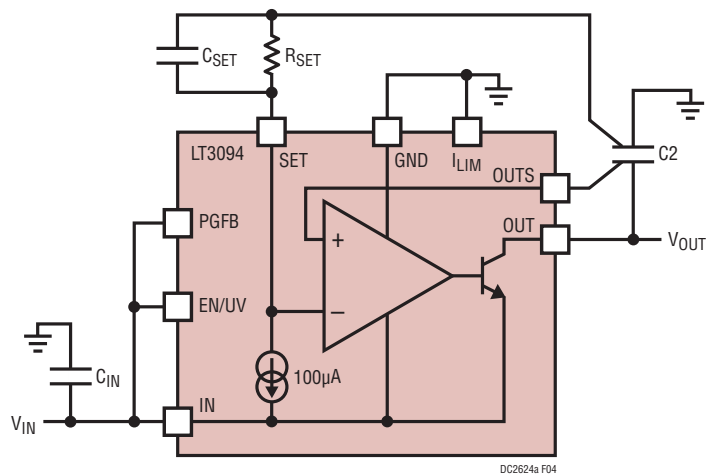


Figure 4. C₂ and C_{SET} Connections for Best Performance

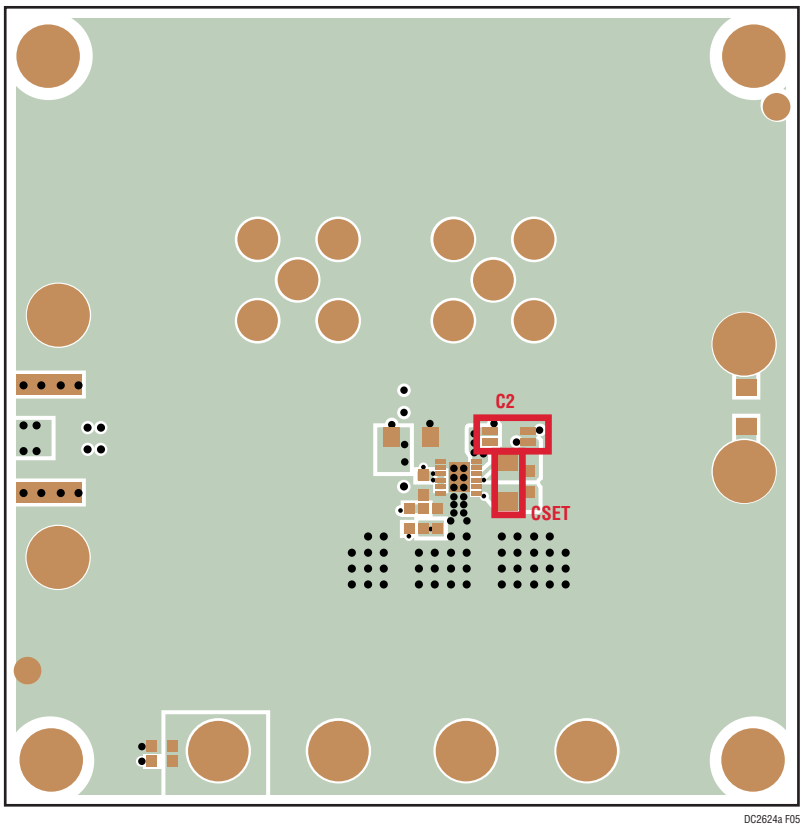


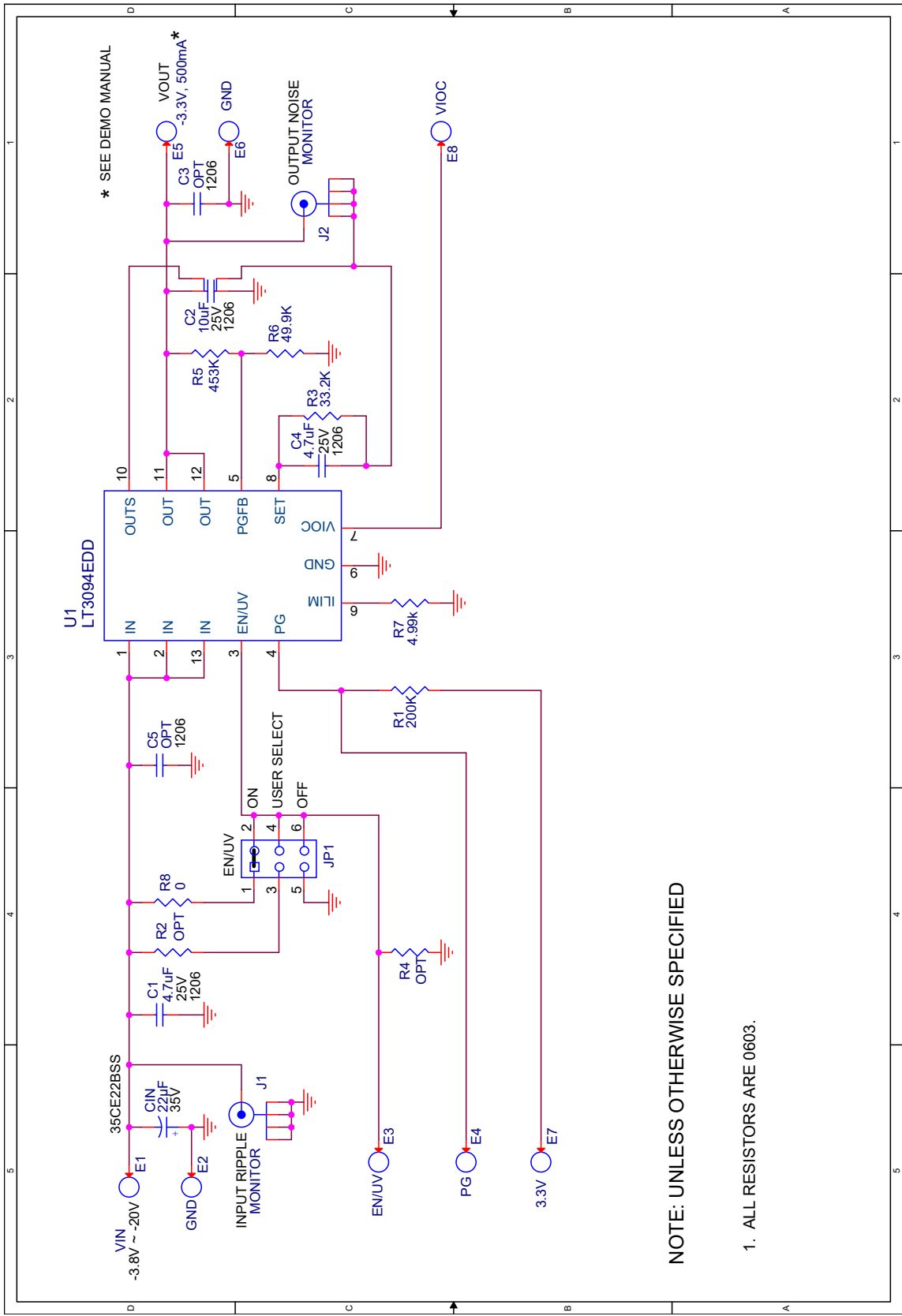
Figure 5. Split Pads for Output Capacitors on Top Layer of DC2624A

DEMO MANUAL DC2624A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1N	CAP, ALUM, 22µF, 35V, 5X5.4MM	SUN ELECTRONIC INDUSTRIES CORP, 35CE22BSS
2	2	C1, C4	CAP, X7R, 4.7µF, 25V, 10% 1206	MURATA, GRM31CR71E475KA88L
3	1	C2	CAP, X5R, 10µF, 25V, 10% 1206	MURATA, GJ831CR61E106KE83L
4	1	R1	RES, CHIP, 200k, 1/10W, 5% 0603	VISHAY, CRCW0603200KJNEA
5	1	R2	RES, CHIP, 100k, 1/10W, 1% 0603	VISHAY, CRCW0603100KFKEA
6	1	R3	RES, CHIP, 33.2k, 1/10W, 1% 0603	VISHAY, CRCW060333K2FKEA
7	1	R5	RES, CHIP, 453k, 1/10W, 1% 0603	VISHAY, CRCW0603453KFKEA
8	1	R6	RES, CHIP, 49.9k, 1/10W, 1% 0603	VISHAY, CRCW060349K9FKEA
9	1	R7	RES, CHIP, 4.99k, 1/10W, 1% 0603	VISHAY, CRCW06034K99FKEA
10	1	U1	IC, LT3094EDD, 12DFN	ANALOG DEVICES, LT3094EDD#PBF
Additional Demo Board Circuit Components				
1	0	C3, C5 (OPT)	CAP, OPTION, 1206	
2	0	R4 (OPT)	RES, OPTION, 0603	
Hardware: For Demo Board Only				
1	8	E1 TO E8	TESTPOINT, TURRET, 0.094" PBF	MILL-MAX, 2501-2-00-80-00-00-07-0
2	2	J1, J2	CONN, BNC, 5 PINS	CONNEX, 112404
3	4	MH1 TO MH4	STAND-OFF, NYLON 6.4mm	WURTH ELEKTRONIK, 702931000

SCHEMATIC DIAGRAM



DEMO MANUAL DC2624A



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 NON-INFRINGEMENT 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.