

LTC6951

Ultralow Jitter Multi-Output Clock Synthesizer with Integrated VCO

DESCRIPTION

Demonstration circuit 2248A features the **LTC®6951**, an Ultralow Jitter Multi-Output Clock Synthesizer with Integrated VCO.

For ease of use, the DC2248A is powered from a single 6V supply and comes installed with a 100MHz reference. Direct access to the LTC6951 5V, 3.3V and the reference supplies is possible by removing jumpers. For evaluation of the LTC6951 with other references, the DC2248A can be modified to accommodate different onboard or external components.

All differential inputs and outputs have 0.5" spaced SMA connectors. The DC2248A has four AC coupled CML outputs with 50Ω transmission lines making them suitable

to drive 50Ω impedance instruments. The LVDS output is DC coupled.

The LTC6951's synchronization functions are made available via the LTC6951 SPI interface, an SMA connector and a turret. The DC2248A can be modified to use an onboard switch and debounce circuit to control the sync pin.

A DC2026 (or DC590B) USB serial controller board is used for SPI communication with the LTC6951, controlled by the supplied LTC6951Wizard™ software.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2248A>

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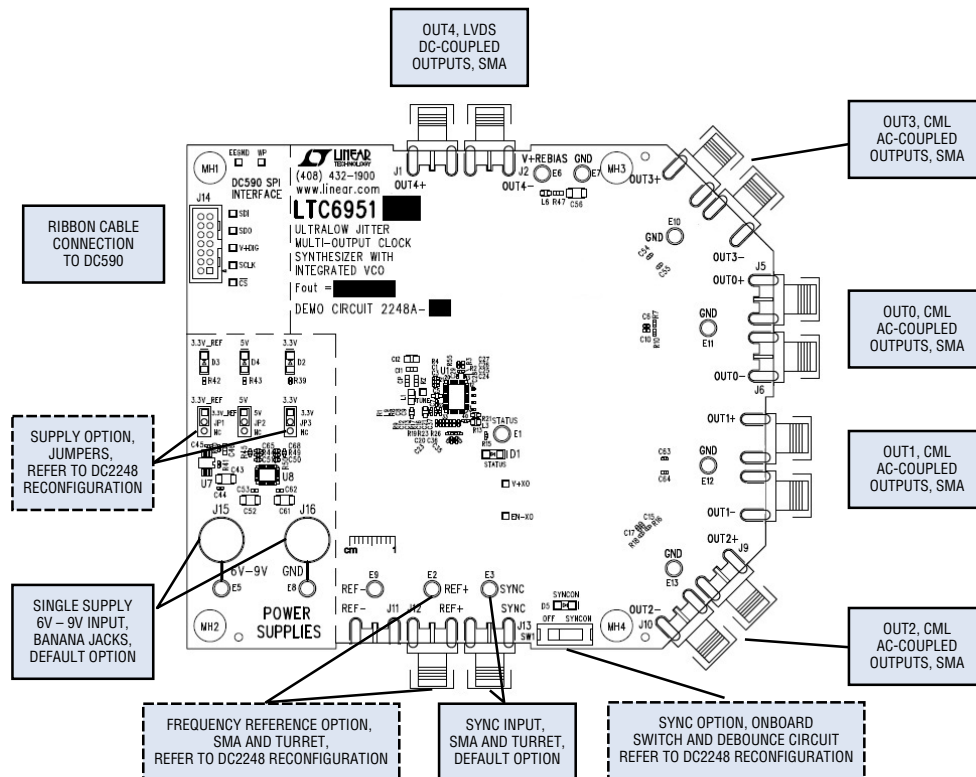


Figure 1. DC2248A Connections

DEMO MANUAL DC2248A

QUICK START PROCEDURE

The DC2248A is easy to set up to evaluate the performance of the LTC6951. Follow the procedure below.

The LTC6951Wizard and the DC2026 (or DC590B) are required to control the DC2248A through a personal computer (PC).

DC2026 and DC590B Configuration

DC2026: Refer to Figure 2. Set the JP3 jumper to the 3.3V (preferred) or 5V position.

DC590B: Refer to Figure 2. Set the JP6 jumper to the 3.3V (preferred) or 5V position. JP4 should select “EN”, JP5 “ISO” and “SW” should both select “ON.”

Connect either the DC2026 (or DC590B) to one of your computer's USB ports with the included USB cable.

The DC2026 has the ability to run Linduino code. Refer to <http://www.linear.com/solutions/linduino> and the Frequently Asked Question section (Question #3) for more details.

LTC6951Wizard Installation

The LTC6951Wizard software is used to communicate with the LTC6951. It uses the DC2026 (or DC590B) to translate between USB and SPI-compatible serial communications formats. It also includes advanced PLL design and simulation capabilities. The following are the LTC6951Wizard system requirements:

- Windows Operating System: Windows XP, Windows 2003 Server, Windows Vista, Windows 7
- Microsoft .NET 3.5 SP1 or later
- Windows Installer 3.1 or later
- Linear Technology's® DC590B or DC2026 (with the DC590B emulator sketch loaded)

The DC2026 arrives from the factory with the DC590B emulator sketch loaded. If this is not the case refer to the Troubleshooting section.

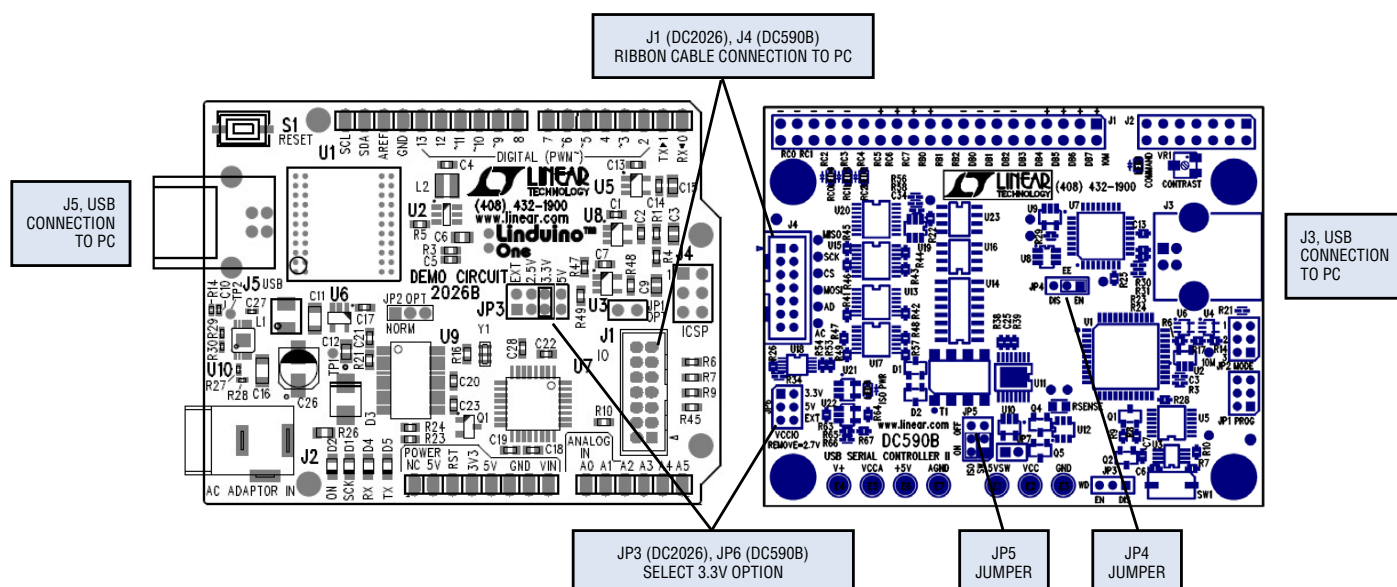


Figure 2. DC2026B and DC590B Jumper and Connector Location

QUICK START PROCEDURE

Download the LTC6951Wizard setup file at www.linear.com/LTC6951Wizard.

Run the LTC6951Wizard setup file and follow the instructions given on the screen. The setup file will verify and/or install Microsoft .NET and install the LTC6951Wizard. Refer to the LTC6951Wizard Help menu for software operation.

DC2248A Configuration

1. Connect J15 and J16 to a power supply and apply power (see Figure 1 and the Typical DC2248A Requirements and Characteristics table). The three green power supply LEDs (D2, D3, D4) should illuminate at this point.

2. Connect the DC2026 (or DC590B) to the DC2248A with the provided ribbon cable.

3. Run the LTC6951Wizard application.

4. In LTC6951Wizard, click **File** → **Load Settings** and select file "ALL_CHAN_600MHz.6951set". The DC2248A's red STATUS LED (D1) should illuminate after step 4. A 600MHz signal should be present on all outputs.

5. Synchronize outputs by toggling the LTC6951 SSYNC bit from the LTC6951Wizard.

Be sure to power down or terminate any unused RF output with 50Ω, or poor spurious performance may result.

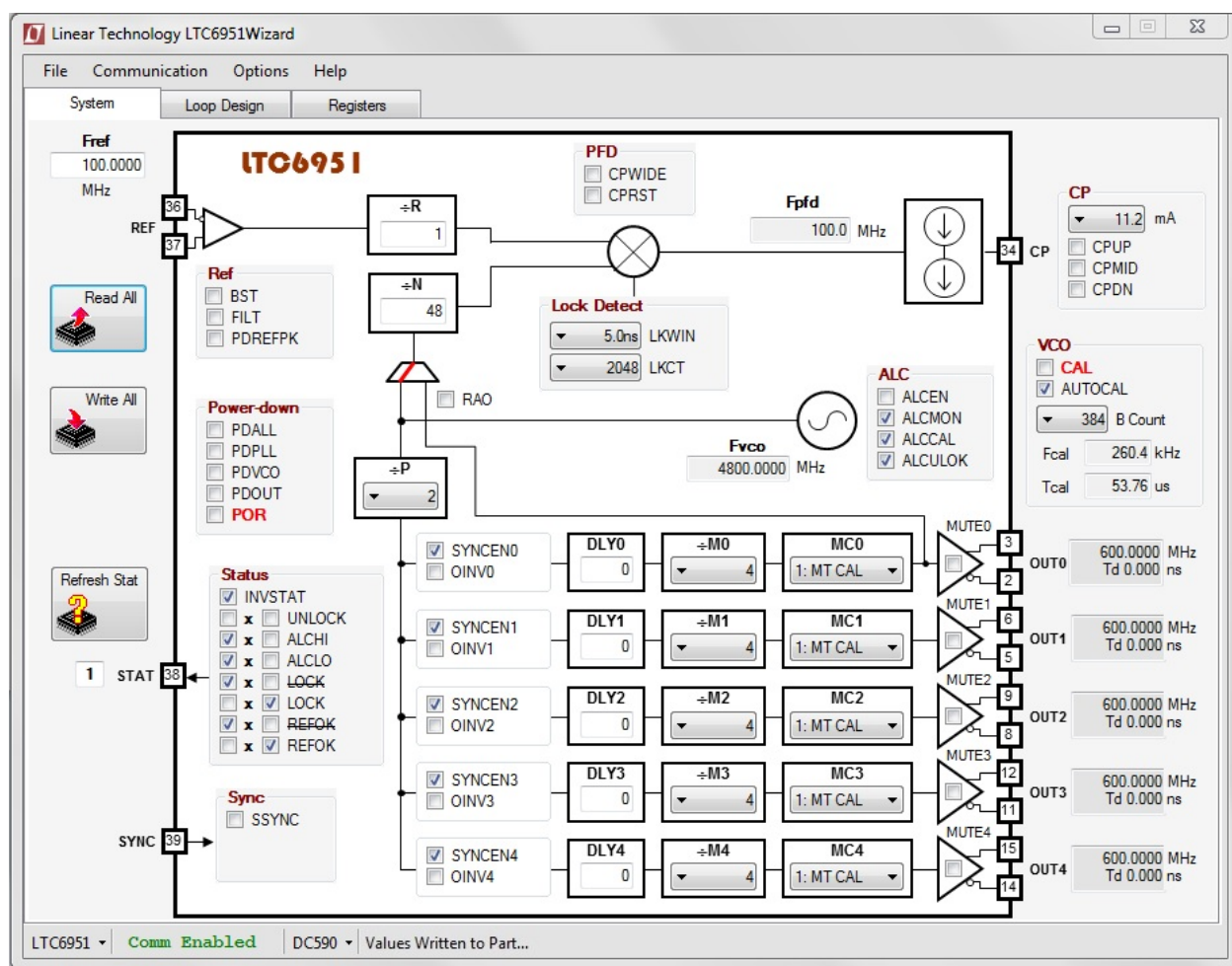


Figure 3. LTC6951Wizard Screenshot

TROUBLESHOOTING

If the green LEDs (D2, D3, or D4) do not illuminate:

1. Verify J15 measures between 6V and 9V (see the Typical DC2248A Requirements and Characteristics table).
2. Verify JP1, JP2, JP3 jumpers are installed correctly (refer to the DC2248A schematic sheet 3).
3. Verify the voltages at JP1, JP2, and JP3 are correct:
 - a. JP1 = 3.3V
 - b. JP2 = 5V
 - c. JP3 = 3.3V

If the red LED (D1) does not illuminate:

1. In LTC6951Wizard's System tab click "Read All". LTC6951Wizard should match Figure 3. If not, see "Verify DC2248A and LTC6951Wizard Communication."
2. In LTC6951Wizard's System tab, Under Status deselect LOCK and select REFOK. If D1 does not illuminate then verify "V+XO" test point reads 3.3V.

Verify DC2248A and LTC6951Wizard Communication:

To verify communication with the DC2248A, the bottom status line in LTC6951Wizard should read "LTC6951" and "Comm Enabled" as shown in Figure 3. If not, then perform the following steps:

1. Ensure the DC2026 (or DC590B) is connected to PC.
2. Disconnect and Reconnect DC2026 (or DC590B) to PC.
3. Ensure DC2026 (or DC590B) is connected to DC2248A.
4. Close LTC6951Wizard and restart.

5. If using the DC2026, Verify the DC2026 has the DC590B Emulator sketch loaded by contacting the factory or following these steps.

- a. Download QuikEval™ at <http://www.linear.com/designtools/software/#Data>
- b. Run QuikEval (Linduino connected to the PC)

If QuikEval does not find a DC590B, reload the DC590B Linduino sketch. To use the LTSketchbook refer to the Linduino Quick Start tab at <http://www.linear.com/solutions/linduino> for instructions on how to start using Linduino.

If DC2248A performance is less than the LTC6951 data sheet specifications or LTC6951Wizard Simulation:

1. For unexpected spurious response, verify power supplies are low noise and spurious free power supplies. Power supplies that are based off a switching regulator architecture are known to generate spurs on PLL/VCO outputs.
2. For poor phase noise results, verify the phase noise specifications of the phase noise measurement instrument. Traditional spectrum analyzers have higher phase noise than the LTC6951 and will degrade measurement results. To measure phase noise performance it is recommended to use a signal source analyzer, such as Keysight's (previously Agilent/HP) E5052.

Contact the factory for further troubleshooting.

DC2248A RECONFIGURATION

The following covers the hardware reconfiguration of the DC2248A. Refer to LTC6951Wizard and the LTC6951 data sheet to better understand how to change programmed parameters on the DC2248A.

Power Supply Options

Table 1 provides the power supply options for DC2248A. Any combination of onboard LDO or external supplies is possible. By default the DC2248A is set up to use the three onboard LDO's.

Table 1. Power Supply Options

VOLTAGE, COMPONENTS	JUMPER	ONBOARD LDO	EXTERNAL SUPPLY
3.3V*, U2 100MHz reference	JP1	Short Jumper Pins 1–2. Apply 6V–9V to J15/J16. (Default Option).	Short Jumper Pins 2–3. Apply appropriate voltage to Jumper Pin 1.
5V, U1 LTC6951	JP2		
3.3V, U1 LTC6951, U3, U4, U5 and U9	JP3		

* When using an external reference, power down the onboard reference by shorting JP1 pins 2–3, or poor spurious performance may result.

LTC6951 6951SET Files

The LTC6951Wizard provides a 6951set file for all LTC6951 data sheet application examples and typical application circuits. After loading a 6951 set file a pop-up window will detail any user actions and board modifications required for the selected file. These same user actions and board modifications are listed in Table 5.

Loop Filter Design and Installation

Use 6951Wizard to select, design and simulate different loop filters (see Frequently Asked Questions section, question #3). Loop filter components RZ, C11, C12, CP, L1 and R1 are located on the top side of the board. Loop filter component C2 is located on the bottom side of the board.

Reference Options

Table 2 details the available reference options and board modifications for each available option. The 6951set files provided assume the frequency and noise profile of the default reference. If a different reference is used, update the reference frequency and noise profile in LTC6951Wizard before simulating the LTC6951 under the Loop Design tab (see Frequently Asked Questions section, question #3 and the LTC6951Wizard Help menu).

Sync Options

The LTC6951 data sheet describes several synchronization modes. After selecting the desired synchronization mode, refer to Tables 3 and 4 to select a synchronization programming option and the resulting DC2248A board modifications. Refer to the LTC6951 data sheet for SYNC timing and level requirements.

CML Outputs (OUT0, OUT1, OUT2, OUT3)

The DC2248A has four AC coupled CML outputs. To drive 50Ω impedance instruments connect OUTx+ to the instrument and OUTx– to a 50Ω termination, or vice versa. Refer to LTC6951 data sheet for differential termination options.

The V+BIAS turret provides an option to set the DC offset level after the AC coupling capacitor. Modifications are required to use the V+BIAS turret; refer to the DC2248A schematic.

LVDS Output (OUT4)

The LVDS output is DC coupled without onboard termination by default. The DC2248A provides series and a differential termination resistor options to accommodate other termination networks described in the data sheet.

Table 2. Reference Options and Board Modifications

DEFAULT OPTION	REFERENCE OPTION	INSTALL	DEPOPULATE	LTC6951 PERFORMANCE	COMMENTS
●	Onboard	NA	NA	Limited by onboard reference at frequency offsets <10kHz	U2 reference footprint supports 5mm x 7.5mm and 14mm x 9mm packages with 4 or 6 pins
	External*	C36 0402 1μF	C35	Best performance when using an ultralow noise external reference	For improved performance connect J12 to an ultralow noise reference, such as the Wenzel 501-04517D.

* When using an external reference, power down the onboard reference by shorting JP1 pins 2-3, or poor spurious performance may result.

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DC2248A RECONFIGURATION

Table 3. LTC6951 Sync Mode Programming Options

LTC6951 SYNC MODE	LTC6951 RAO BIT	SYNC PROGRAMMING OPTIONS (See Table 4 for Board Modifications)				COMMENTS
		LTC6951 SSYNC BIT	ONBOARD SYNC SWITCH (SW1)*	SYNC SMA	SYNC SMA AND REF+ SMA	
EZSync, STANDALONE	0	●	●	●	●	
EZSync, CONTROLLER	0		●	●	●	Modify follower-driver outputs to be DC-coupled, refer to LTC6951 and follower part number data sheets for correct termination networks.
EZ204Sync	1	●	●	●	●	
EZParallelSync	1	●	●	●	●	
ParallelSync	1				●	

* SW1 output is connected to a debounce circuit to ensure the SYNC pin receives a clean sync signal

Table 4. DC2248A Board Modifications for LTC6951 Sync Programming Options

DEFAULT OPTION	SYNC PROGRAMMING OPTION	R13	R54	U2, REFERENCE	COMMENTS
●	LTC6951 SSYNC bit	1kΩ	Do Not Install	Onboard or External, See Table 2	Refer to LTC6951 data sheet for EZSync timing requirements.
	Onboard Sync Switch (SW1)	Depopulate	0Ω	Onboard or External, see Table 2	
	SYNC SMA	Depopulate	Do Not Install	Onboard or External, see Table 2	
	SYNC SMA and REF+ SMA	Depopulate	Do Not Install	External Only, see Table 2	When using ParallelSync™ refer to LTC6951 data sheet for REF+ and SYNC pins timing requirements.

Table 5. LTC6951Wizard Settings File

LTC6951Wizard FILE NAME	USER ACTIONS	BOARD MODIFICATIONS
ALL_CHAN_600MHz	Toggle LTC6951 SSYNC register bit	NA
6951_EZSYNC_STANDALONE 6951-1_EZSYNC_STANDALONE	Toggle LTC6951 SSYNC register bit	NA
6951_EZSYNC_MULTI-CHIP 6951-1_EZSYNC_MULTI-CHIP	Toggle LTC6951 & LTC6954 SYNC Pin (EZSync timing)	Refer to Tables 3 (EZSync CONTROLLER) and 4
6951_ParallelSync_MULTI-CHIP 6951-1_ParallelSync_MULTI-CHIP	Toggle LTC6951 CAL register bit Toggle LTC6951 SYNC pin (SYNC to REF timing)	Refer to Table 2 (External Reference) Refer to Tables 3 (ParallelSync) and 4 Loop Filter (values provided in LTC6951Wizard File)
6951_JESD204B 6951-1_JESD204B	Toggle LTC6951 SSYNC register bit	Refer to Table 2 (External Reference) Loop Filter (values provided in LTC6951Wizard File)
6951_FrontPage_LTC2107	NA	NA
6951_ParallelSyncw6954	Toggle LTC6951 CAL register bit Toggle LTC6951 SYNC pin (SYNC to REF timing)	Refer to Tables 3 (ParallelSync) and 4
6951_JESD204B_LTC2123	Toggle LTC6951 SSYNC register bit	NA

ASSEMBLY OPTIONS

Table 6. DC2248A Options and Frequency Ranges

ASSEMBLY VERSION	PART NUMBER	FREQUENCY RANGE
DC2248A-A	LTC6951IUHF	1.95MHz to 2500MHz
DC2248A-B	LTC6951IUHF-1	2.1MHz to 2700MHz

FREQUENTLY ASKED QUESTIONS

1 How do I use LTC6951Wizard to design a different setup and loop filter, simulate results and program the LTC6951?

In the LTC6951Wizard, select Help: Menu → Help. The help file discusses the function of all LTC6951Wizard menus and tabs. The help file also provides a step by step example describing how to design a different frequency plan, design and simulate a loop filter, and how to program the LTC6951 with these new settings.

2. Can the LTC6951Wizard control an LTC6951 on a board other than the DC2248A?

Yes, connect the DC2026 (or DC590) SPI lines to the SPI interface of the LTC6951. Also, the LTC6951Wizard allows communication to the DC2248A by sensing resistors R34 and R35 in the DC2248A schematic. If these resistors are not present, the LTC6951Wizard

will not communicate with the LTC6951. To allow LTC6951Wizard communication to other hardware, install equivalent resistors in the appropriate location on the backside of DC2026 J1 connector (or DC590B J4 connector).

3. Does the LTC6951 have Linduino Code available?

Yes, download the LTC6951 sketch in the LTSketchbook. To use the LTSketchbook and for instructions on how to start using Linduino, refer to the Linduino QuickStart tab at <http://www.linear.com/solutions/linduino>. This will give programmers a head start in writing code for the LTC6951. It is recommended to use LTC6951Wizard to create the best possible register settings for all conditions. These LTC6951 register settings from LTC6951Wizard can be programmed in a lookup table. At this point the lookup table and LTC6951 sketch can aid in program development.

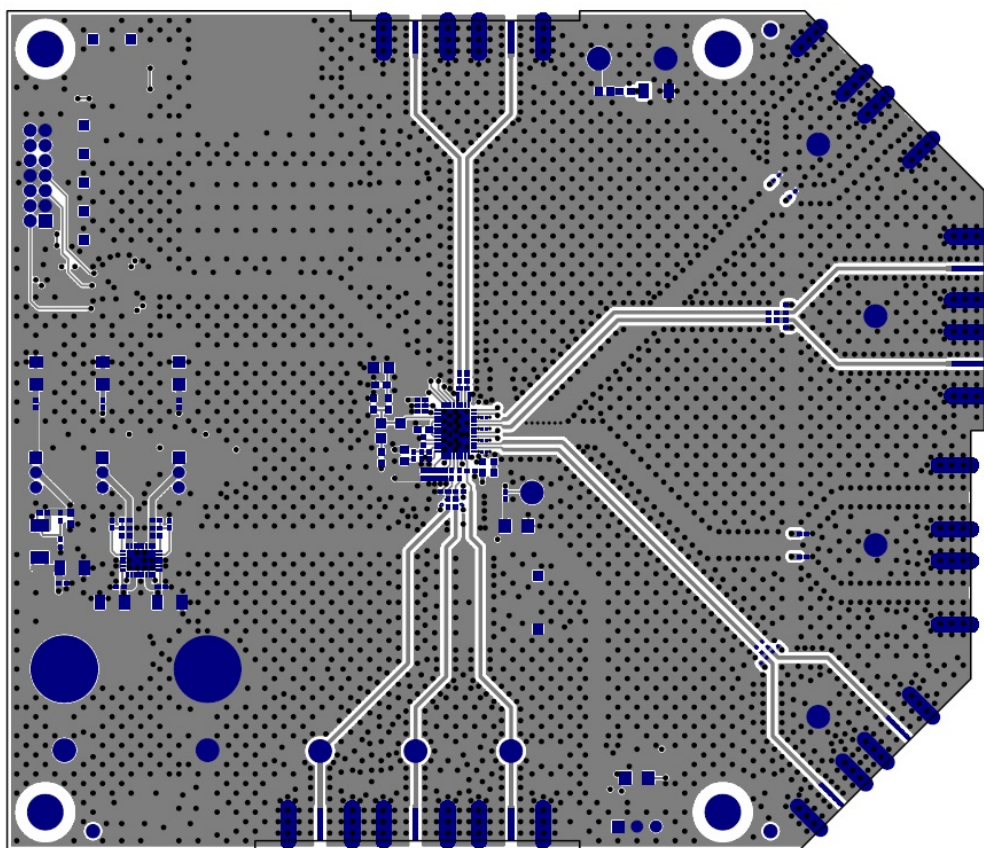
TYPICAL DC2248A REQUIREMENTS AND CHARACTERISTICS

PARAMETER	INPUT OR OUTPUT	PHYSICAL LOCATION	DETAILS
6V to 9V Power Supply	Input	J15 and J16 BNC banana jacks	Default option, single supply: 6V–9V low-noise and spur-free supply, 500mA*; Green LEDs D2, D3, and D4 illuminate when power supplied.
OUT4 ⁺ , OUT4 [–]	Two Outputs	J1 and J2 SMA connectors**	LVDS, DC coupled, 600MHz, 750mVpk differential, 1.23V DC offset (if powered up)*. Requires 100Ω differential termination.
OUT3 ⁺ , OUT3 [–]	Two Outputs	J3 and J4 SMA connectors**	CML, AC coupled, 600MHz, 800mVpk differential.*
OUT0 ⁺ , OUT0 [–]	Two Outputs	J5 and J6 SMA connectors**	CML, AC coupled, 600MHz, 800mVpk differential.*
OUT1 ⁺ , OUT1 [–]	Two Outputs	J7 and J8 SMA connectors**	CML, AC coupled, 600MHz, 800mVpk differential.*
OUT2 ⁺ , OUT2 [–]	Two Outputs	J9 and J10 SMA connectors**	CML, AC coupled, 600MHz, 800mVpk differential.*
SYNC	Input	J13 SMA connector or SYNC turret	Default option, 1kΩ pull-down resistor. See Tables 3 and 4, to ensure correct option is selected.
STAT	Output	STATUS turret	Red LED D1 illuminates when STAT pin in high state.
Loop Bandwidth	–	Set by loop filter component values	344kHz*
3.3V Onboard Reference Supply	Input	JP1, Pin 1	Board modifications required for use, see Table 1.
5V LTC6951 Supply	Input	JP2, Pin 1	Board modifications required for use, see Table 1.
3.3V LTC6951 Supply	Input	JP3, Pin 1	Board modifications required for use, see Table 1.
REF ⁺	Input	J12 SMA connector or REF ⁺ turret	Board Modifications required for use, see Table 2. By default an onboard reference (U2) is connected.
REF [–]	Input	J11 SMA connector or REF [–] turret	By default NOT INSTALLED.
TUNE	Output/Input	Test point	Debug Only: connected to LTC6951 TUNE pin.
V ⁺ BIAS	Input	V ⁺ BIAS turret	Board modifications required for use, refer to the schematic.

*These values are for the “ALL_CHAN_600MHz.6951set” file and the default onboard reference.

**Any unused RF output must be powered down or terminated with 50Ω, or poor spurious performance may result.

PCB LAYOUT



Top Layer

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C11	CAP, X7R, 68nF, 50V, 10%, 0603	MURATA, GRM188R71H683KA93D
2	0	C12	CAP, 0805	OPT
3	1	CP	CAP, X7R, 1200pF, 50V, 10%, 0603	MURATA, GRM188R71H122KA01D
4	7	C1, C9, C13, C19, C45, C50, C51	CAP, X7R, 0.01μF, 16V, 10%, 0402	AVX, 0402YC103KAT2A
5	1	C2	CAP, X7R, 820pF, 50V, 10%, 0603	MURATA, GRM188R71H821KA01
6	1	C3	CAP, X5R, 470nF, 10V, 10%, 0402	AVX, 0402ZD474KAT2A
7	19	C4, C6, C10, C11, C14-C17, C38-C42, C44, C53, C58, C62, C71, C72	CAP, X7R, 0.1μF, 10V, 10%, 0402	AVX, 0402ZC104KAT2A
8	2	C5, C46	CAP, X7R, 1.0μF, 16V, 10%, 0603	TDK, C1608X7R1C105K
9	12	C7, C8, C12, C18, C21, C30-C35, C37	CAP, X5R, 1.0μF, 16V, 10%, 0402	AVX, 0402YD105KAT2A
10	0	C20, C23, C36, C54, C55, C59, C60, C63-C68	CAP, 0402	OPT
11	7	C22, C43, C49, C52, C57, C61, C70	CAP, X7R, 10μF, 25V, 10%, 1206	MURATA, GRM31CR71E106KA12L
12	6	C24-C29	CAP, X7R, 0.01μF, 6.3V, 10%, 0201	AVX, 02016C103KAT2A
13	3	C47, C48, C69	CAP., TANT., 330μF, 10V, 10%, 7343	AVX, TPME337K010R0035

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DEMO MANUAL DC2248A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
14	0	C56	CAP., 1206	OPT
15	1	D1	LED, RED, LED-ROHM-SML-010VT	ROHM, SML-010VTT86L
16	3	D2, D3, D4	LED, GREEN, LED-ROHM-SML-010FT	ROHM, SML-010FTT86L
17	1	D5	LED, YELLOW, LED-ROHM-SML-010YT	ROHM, SML-010YTT86L
18	11	E1-E11	TURRET, TESTPOINT 0.064"	MILL-MAX, 2308-2-00-80-00-00-07-0
19	0	E12	TURRET, TESTPOINT 0.064"	OPT
20	3	JP1, JP2, JP3	JMP, HD1X3, .079CC	SULLINS, NRPN031PAEN-RC
21	12	J1-J10, J12, J13, J11	CONN., SMA 50-OHM EDGE-LAUNCH	EMERSON, 142-0701-851
23	1	J14	CONN., HEADER, 14 PIN, 2mm	MOLEX, 87831-1420
24	2	J15, J16	JACK, BANANA	KEYSTONE, 575-4
25	1	L1	IND., 0 Ω , 0805	VISHAY, CRCW08050000Z0EA
26	8	L2-L9	IND, FERRITE BEAD, L-0603LS-1608	TAIYO YUDEN, FBMH1608HL331-T
27	2	R1, RZ	RES., CHIP, 63.4, 1%, 0603	NIC, NRC06F63R4TRF
28	0	R2, R5-R7, R10, R11, R14, R16, R18, R20, R22-R24, R53, R54	RES., 0402	OPT
29	6	R3, R4, R8, R17, R19, R55	RES., CHIP, 0, 0402	VISHAY, CRCW04020000Z0EA
30	1	R9	RES., CHIP, 10, 1/16W, 1%, 0402	VISHAY, CRCW04210ROFKED
31	3	R12, R39, R42	RES., CHIP, 280 1/16W, 5%, 0402	NIC, NRC04J281TRF
32	1	R13	RES., CHIP, 1k, 1/16W, 1%, 0402	NIC, NRC04F1001TRF
33	1	R15	RES., CHIP, 330, 1/16W, 1%, 0402	NIC, NRC04F3300TRF
34	3	R21, R36, R47	RES., CHIP, 0 Ω , 0603	NIC, NRC06Z0TRER
35	5	R25, R28, R29, R30, R37	RES., CHIP, 100 Ω 1/16W, 5%, 0402	NIC, NRC04J101TRF
36	1	R26	RES., CHIP, 49.9 Ω , 1/16W, 1%, 0402	NIC, NRC04F49R9TRF
37	4	R27, R31, R32, R38	RES., CHIP, 200k, 1/16W, 1%, 0402	NIC, NRC04F2003TRF
38	5	R33, R34, R35, R51, R52	RES., CHIP, 4.99k, 1/16W, 1%, 0402	NIC, NRC04F4991TRF
39	1	R40	RES., CHIP, 17.8k, 1/16W, 1%, 0402	NIC, NRC04F1782TRF
40	3	R41, R45, R50	RES., CHIP, 10k, 1/16W, 1%, 0402	VISHAY, CRCW040210KOFKED
41	1	R43	RES., CHIP, 619 Ω 1/16W, 1%, 0402	NIC, NRC04F6190TRF
42	1	R44	RES., CHIP, 31.6k, 1/16W, 1%, 0402	NIC, NRC04F3162TRF
43	2	R46, R48	RES., CHIP, 1M, 1/16W, 1%, 0402	NIC, NRC04F1004TRF
44	1	R49	RES., CHIP, 17.4k, 1/16W, 1%, 0402	NIC, NRC04F1742TRF
45	1	SW1	SWITCH, SLIDE SPDT 30V 0.2A, SW-EG1218	E-SWITCH, EG1218
46	1	U1	I.C., QFN40UHF-5X7	LINEAR TECH., LTC6951IUHF
47	1	U2	I.C., 100MHz OSCILLATOR, OSC-VCXO/CVS575S	CRYSTEK, CCHD-575-25-100.00
48	2	U3, U4	I.C., DUAL BUFFER, SC70-6	FAIRCHILD SEMI., NC7WZ17P6X
49	1	U5	I.C., SINGLE BIT, DUAL SUPPLY, 3-STATE OUTPUT, SOT363	NXP SEMI., 74LVC1T45GW
50	1	U6	I.C., SERIAL EEPROM, TSSOP8	MICROCHIP, 24LC025-I /ST
51	1	U7	I.C., 300mA LOW NOISE LDO REGULATOR, MS8	LINEAR TECH., LT1962EMS8
52	1	U8	I.C., REG LDO ADJ 0.75A/0.25A, QFN28UFD-4X5	LINEAR TECH., LT3030EUFD
53	1	U9	I.C., DUAL 2-INPUT POSITIVE-NAND GATE, US8	TI, SN74LVC2G00DCU
53	3	SHUNT ON JP1-JP3 PINS 1&2	SHUNT, 2mm CTRS.	SAMTEC 2SN-BK-G

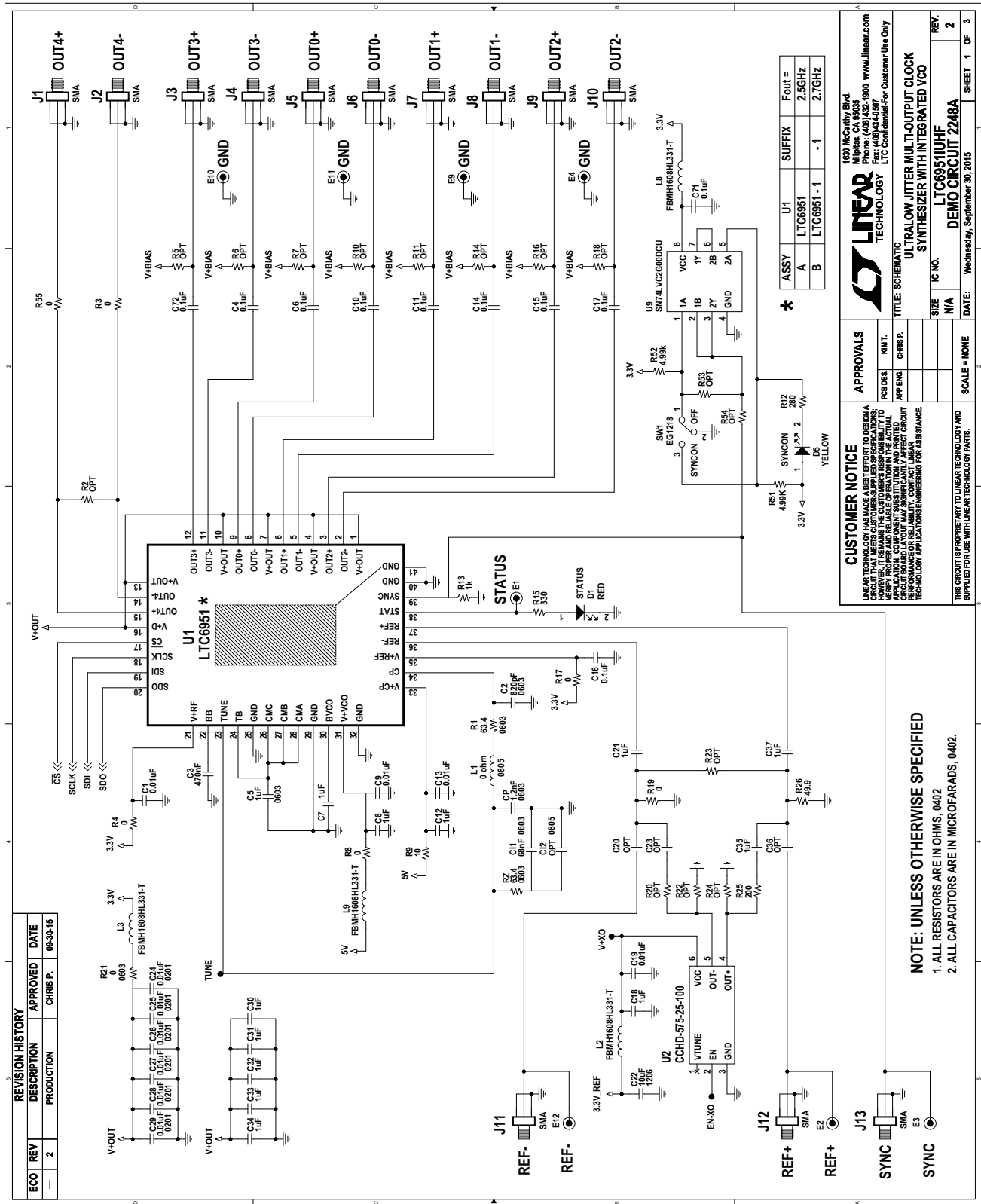
DC2248A-A Required Circuit Components

1	1		DC2248A2-GENERAL BOM	
2	1	U1	I.C., QFN40UHF-5X7	LINEAR TECH., LTC6951IUHF

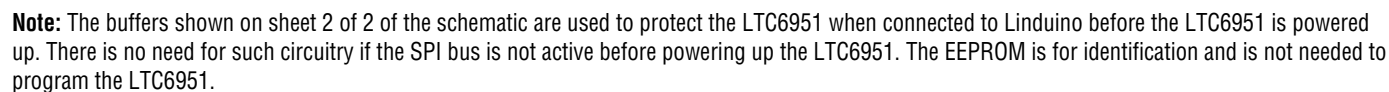
DC2248A-B Required Circuit Components

1	1		DC2248A2-GENERAL BOM	
2	1	U1	I.C., QFN40UHF-5X7	LINEAR TECH., LTC6951IUHF-1

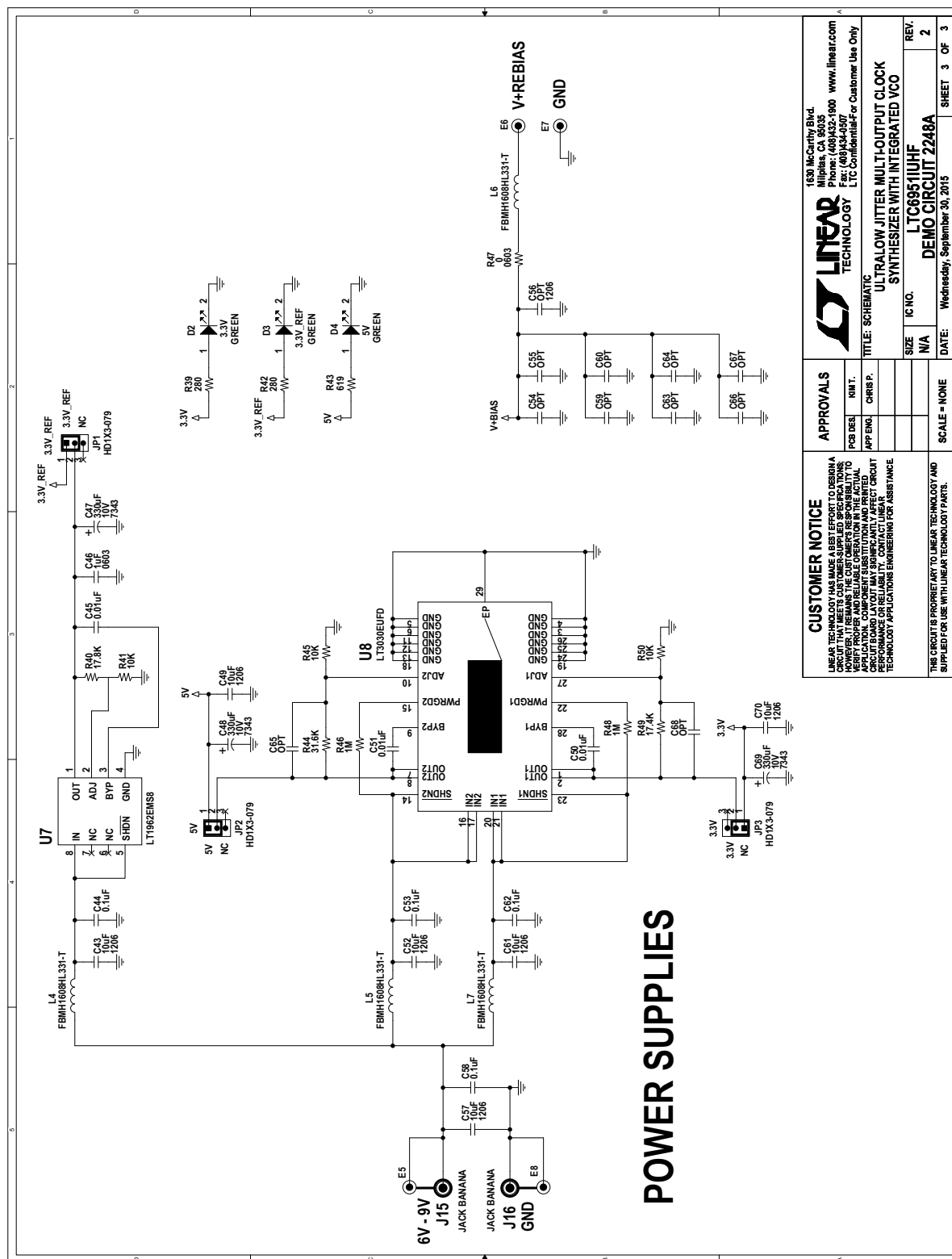
SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL DC2248A

DEMONSTRATION BOARD IMPORTANT NOTICE

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