LTC6945
Ultralow Noise and Spurious
Integer-N Synthesizer

DESCRIPTION

Demonstration circuit 1649A features the LTC®6945, an ultralow noise and spurious integer-N synthesizer.

DC1649A provides 50Ω SMA connectors for the reference frequency (REF+), the reference output buffer (REFO), and the two single-ended RF outputs (RF+ and RF–).

Demonstration circuit 590 is used for SPI communication with the LTC6945, controlled by the supplied PLLWizard™ software.

Design files for this circuit board are available at http://www.linear.com/demo
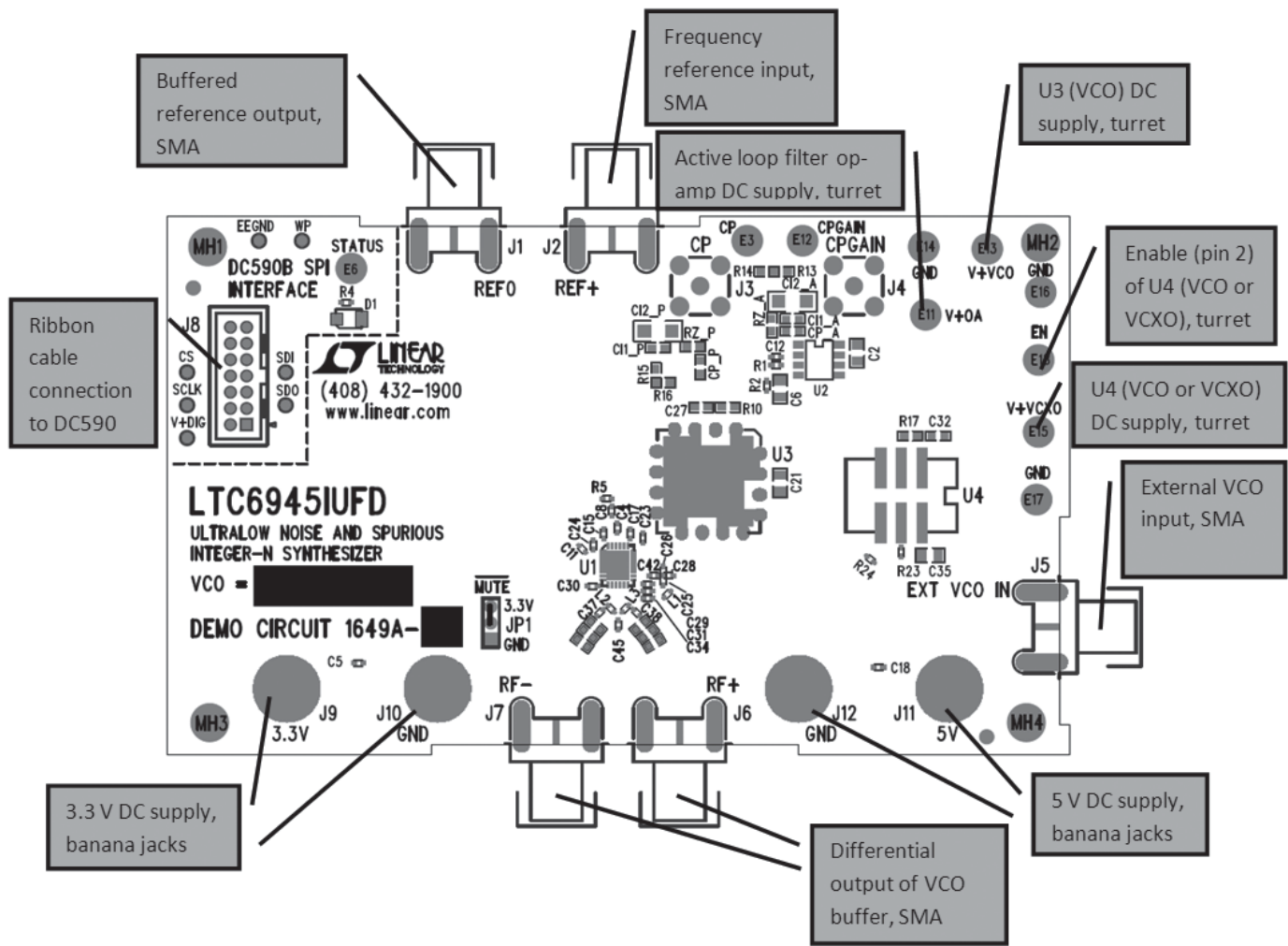
Figure 1. DC1649A Inputs and Outputs

TYPICAL DC1649A REQUIREMENTS AND CHARACTERISTICS

PARAMETER	INPUT OR OUTPUT	PHYSICAL LOCATION	DETAILS
3.3V Power Supply	Input	J9 and J10 Banana Jacks	Low Noise and Spur-Free 3.3V, 95mA
5V Charge Pump Power Supply	Input	J11 and J12 Banana Jacks	Low Noise and Spur-Free 5V, 35mA
5V VCO Power Supply	Input	"V+VCO" Turret	Low Noise and Spur-Free 5V, 18mA
REF+, Reference Frequency	Input	J2 SMA Connector	Low Noise 10MHz or 100MHz*, 6dBm into 50Ω, See Note 1
REFO, Buffered Reference	Output	J1 SMA Connector	Frequency = f$_{REF}$, 0dBm
RF+ and RF–	Two Outputs	J6 and J7 SMA Connectors	902MHz to 928MHz* in 250kHz* Steps, 0dBm
Loop Bandwidth		Set by Loop Filter Component Values	7kHz*

*These frequencies are for the "DC1649A-10MHz.pllset "or" DC1649A-100MHz.pllset" files and included VCO.

Note 1: A low noise 10MHz or 100MHz reference frequency, such as the Wenzel 501-04608A or 501-04516D OCXO, is recommended. If using a different frequency, make sure to update the Fref and R_DIV boxes under the System tab in PLLWizard so that Fpfd is still 250kHz. For example, if a 20MHz clock is used, Fref should be changed to 20MHz and R_DIV to 80.

Ref BST and FILT under the System tab in PLLWizard might need to be changed if the reference frequency and/or power is different than what is recommended in the table above. More information can be found in the LTC6945 data sheet.

QUICK START PROCEDURE

The DC590 and PLLWizard application are required to control the DC1649A through a personal computer (PC).

DC590B Configuration

The DC590's QuikEval™ drivers must be installed before the DC590 will be able to communicate with the LTC6945. To configure the DC590, follow the procedure below, starting with Step 1. If you have already installed the DC590 software previously, skip to Step 5.

Note: Once the QuikEval software is installed, the application *Does Not* need to be executed to run PLLWizard or to control the DC1649A.

1. Do Not plug in the DC590 before running the installation program.

2. Download the QuikEval installation program from http://www.linear.com/software.

3. Run the QuikEval installation program and follow the on-screen instructions. More detailed installation information may be found in the DC590's Quick Start guide.

4. *Exit the QuikEval program once the installation is complete, as it is not needed to run the PLLWizard software.*

5. Place the DC590 jumpers in the following positions:

   JP4 - EE Must be in the "EN" position.

   JP5 - ISO "ON" must be selected.

   JP5 - SW "ON" must be selected.

   JP6 - VCCIO "3.3V" must be selected. This sets the SPI port to 3.3V operation.

6. Connect the DC590 to one of your computer's USB ports with the included USB cable.
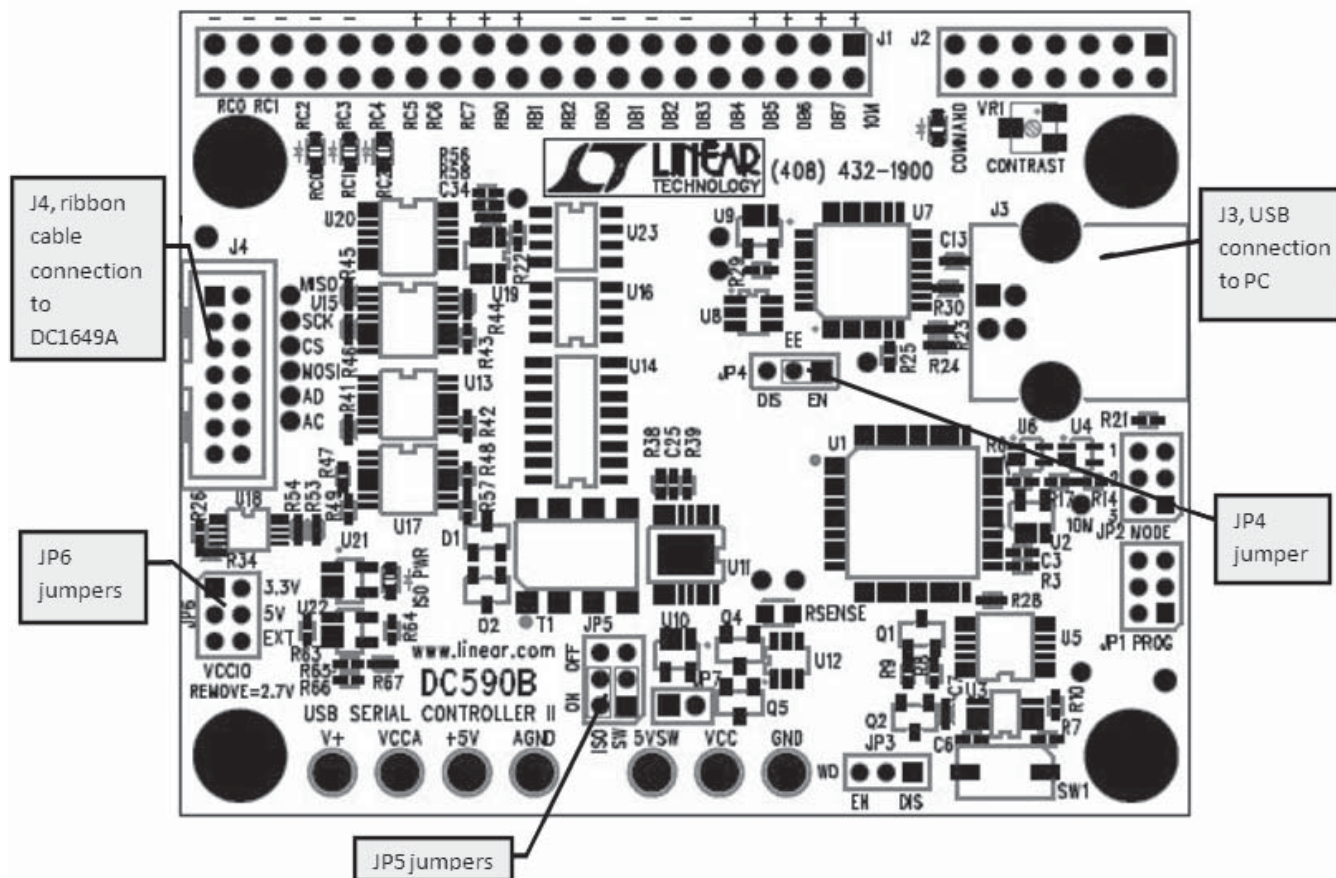
QUICK START PROCEDURE

Figure 2. DC590 Jumper and Connector Locations

PLLWizard Installation

The PLLWizard software is used to communicate with the LTC6945 synthesizer. It uses the DC590 to translate between USB and SPI-compatible serial communications formats. It also includes advanced PLL design and simulation capabilities. The following are the PLLWizard system requirements:

- Windows Operating System: Windows XP, Windows 2003 Server, Windows Vista, Windows 7

- Microsoft .NET 2.0 or later

- Windows Installer 3.1 or later

- Linear Technology's QuikEval and DC590 hardware

Microsoft .NET

You must have Microsoft .NET 2.0 or later installed on your computer. PLLWizard will not run without it. Note

that Windows Vista and Windows 7 have at least version 3.5 preinstalled.

To manually determine your version of .NET using Windows XP, click

Start Menu → Settings → Control Panel → Add or Remove Programs

Depending upon your .NET version, choose one of two PLLWizard setup programs, downloaded from http://www.linear.com/software.

Either setup program will automatically install Microsoft .NET if a compatible .NET version is *not found*. But, the installation source depends upon which file you downloaded from Linear Technology's website. You should pick one of the following two choices, depending upon your version of .NET.

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QUICK START PROCEDURE

Table 1. PLLWizard Installation File

FILE	.NET 2.0 SOURCE
PLLWizardSetup.exe	latest version downloaded from Microsoft
PLLWizardSetup_net20.exe	2.0 SP2 included (much larger file size)

■ Choose *PLLWizardSetup* if you have .NET 2.0 or later, have Windows Vista or Windows 7, or if you have less than .NET 2.0 but want the latest .NET installed.

■ Choose *PLLWizardSetup_net20* if you have less than .NET 2.0, and want faster installation (no additional Microsoft downloads are needed, but the file size is much larger).

The setup file will verify and/or install Microsoft .NET and install PLLWizard. Refer to the Help menu for software operation.
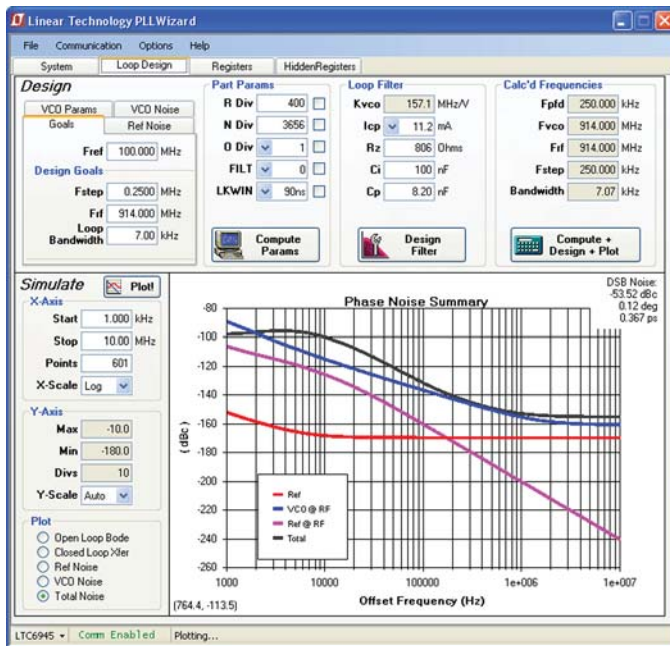

Figure 3. PLLWizard Screenshot

DC1649A Configuration

1. Connect an appropriate reference frequency source (at J2) and signal analyzers (at J6 and/or J7) using the SMA connectors (see Figure 1 and the Typical DC1649A Requirements and Characteristics table).

2. Choose the $\overline{\text{MUTE}}$ jumper setting: **JP1 - GND/3.3V** $\overline{\text{MUTE}}$ position. Select GND to mute the RF output, 3.3V to un-mute.

3. Connect the GND, 3.3V, and 5V banana jacks and the "V+VCO" turret to a power supply and apply power (see Figure 1 and the Typical DC1649A Requirements and Characteristics table).

4. Connect the DC590 to the DC1649A with the provided ribbon cable.

5. Run the PLLWizard application.

6. In PLLWizard, click *File → Load Settings* and point to the "DC1649A-10MHz.pllset" or "DC1649A-100MHz.pllset" file found in the PLLWizard installation directory (typically Program Files → LTC → PLLWizard → Set Files).

The red LED on DC1649A should turn on indicating that the loop is locked at 914MHz.

Troubleshooting

If the red LED does not illuminate, follow the instructions below:

1. Verify that you are able to communicate with the DC1649A. The bottom status line in PLLWizard should read "LTC6945" and "Comm Enabled". Refer to PLL-Wizard's Troubleshoot and Help if not.

2. Verify that the 3.3V, 5V and "V+VCO" have the correct voltages on them and that the reference frequency is applied to the REF+ SMA input.

If the red LED is on but you cannot detect an RF output, make sure jumper JP1 is at the 3.3V position. Run Help → Troubleshoot in PLLWizard if the problem is not resolved.

DC1649A RECONFIGURATION

DC1649A is flexible and allows the use of a variety of VCOs and the choice to employ either an active or passive loop filter. The following covers the hardware reconfiguration of DC1649A. Refer to PLLWizard's Help and the LTC6945 data sheet to better understand how to change programmed parameters on the DC1649A.

Installing Different Tunable Devices

DC1649A permits the use of different tunable oscillators, like VCOs and VCXOs. There are two different oscillator footprints on the board: U3, which accommodates the popular 0.5in × 0.5in package, and U4, which accommodates another common 14mm × 9mm package with four or six pins. An external connectorized VCO can also drive the LTC6945 through J5. Table 2 gives options to customize the DC1649's VCOs. When using an active loop filter, an additional pole is required in the loop filter to limit the op amp's noise contribution to the VCO phase noise.

Selecting Loop Filter Type

DC1649A can use either an active or a passive loop filter, depending upon the application. Some VCO tuning voltage ranges are greater than the LTC6945 charge pump voltage range (refer to the LTC6945 data sheet). In such cases, an active loop filter using an op amp can deliver the required tuning voltage. Table 3 summarizes these options. PLLWizard helps determine the component values listed in this table.

Table 2. Oscillator Options

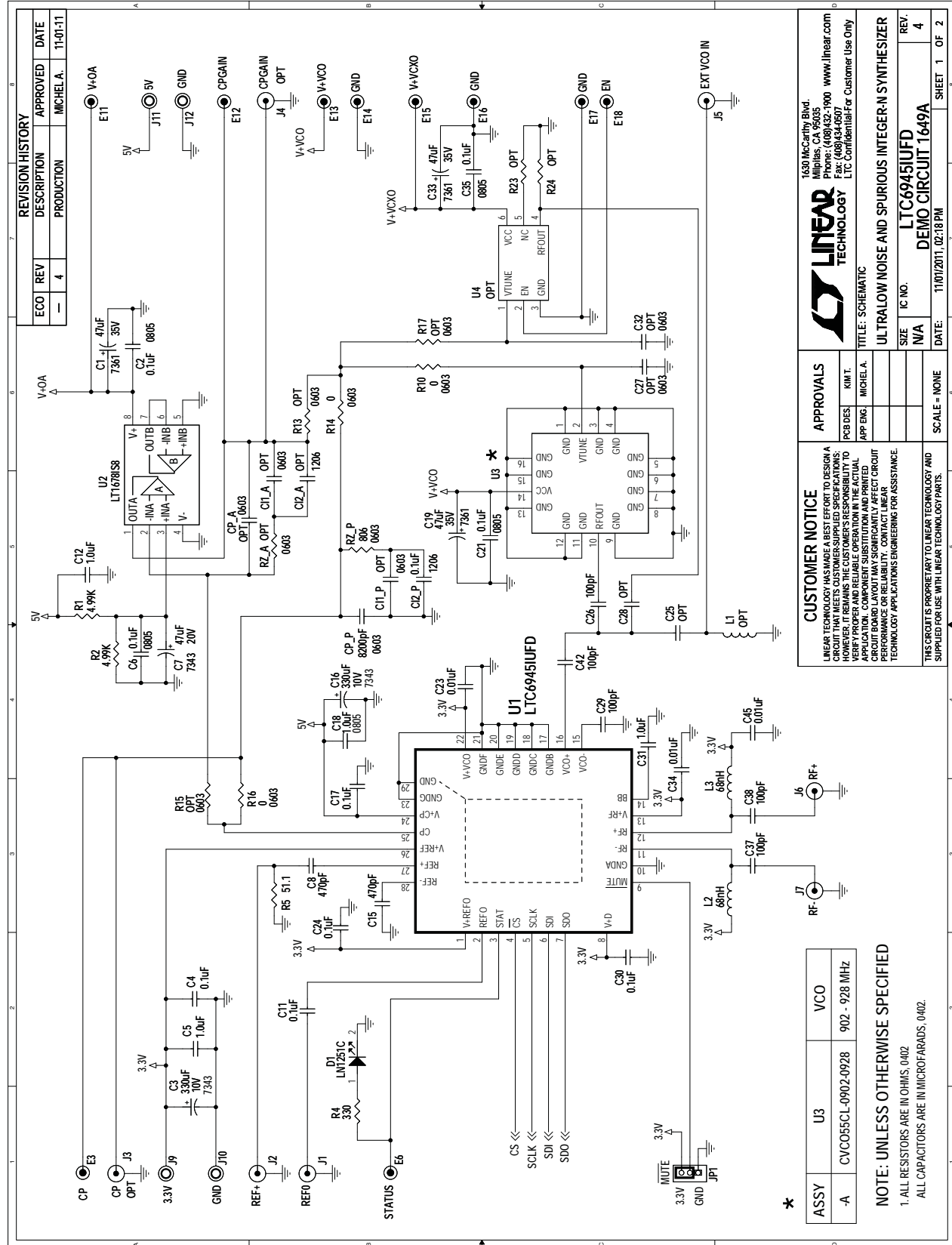| TUNABLE DEVICE	SELECTION COMPONENTS	RESISTOR FOR ADDITIONAL POLE	CAPACITOR FOR ADDITIONAL POLE	POWER	ENABLE PIN OR REMARKS
U3	C26 ≅ 100pF; depopulate R17, C25 and C28	R10 = 0Ω for passive loop filter R10 ≅ 100Ω for active loop filter	C27 = Open for passive loop filter Pick C27 such that $1/(2\pi \cdot R10 \cdot C27) \cong 15 \cdot$ the loop bandwidth in Hz for active loop filter	Determined by U3 device power supply specification, up to 24V applied to "V+VCO" turret	
U4	C28 ≅ 100pF; depopulate R10, C25 and C26	R17 = 0Ω for passive loop filter R17 ≅ 100Ω for active loop filter	C32 = Open for passive loop filter Pick C32 such that $1/(2\pi \cdot R17 \cdot C32) \cong 15 \cdot$ the loop bandwidth in Hz for active loop filter	Determined by U4 device power supply specification, up to 24V applied to "V+VCXO" turret	Use "EN" turret to control pin 2 of U4
External	C25 ≅ 100pF; R15 = 0Ω, depopulate R13, C26 and C28				Selection components are for an active loop filter. Connect the external VCO output to J5. Use "CPGAIN" to tune the external device

Table 3. Loop Filter Options

LOOP FILTER TYPE	SELECTION RESISTORS	RZ FROM PLLWizard	CI FROM PLLWizard	CP FROM PLLWizard	POWER	CPINV BOX, SYSTEM TAB IN PLLWizard
Passive	R14 and R16 = 0Ω, depopulate R13 and R15	RZ_P	CI1_P in parallel with CI2_P	CP_P	None	Unchecked
Active	R13 (except when using an external VCO) and R15 = 0Ω, depopulate R14 and R16	RZ_A	CI1_A in parallel with CI2_A	CP_A	Determined by the maximum allowed tune voltage of the populated VCO (U3 or U4), up to 24V applied to "V+OA" turret	Checked

PARTS LIST   Number of Boards = 325

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	0	CI1_P, CI1_A, C27, C32, CP_A	Opt., 0603	
2	0	CI2_A	Opt., 1206	
3	1	CI2_P	Cap., C0G, 0.1µF, 50V, 5%, 1206	Murata, GRM31C5C1H104JA01L
4	1	CP_P	Cap., X7R, 8200pF, 50V, 10%, 0603	Murata, GRM188R71H822KA01D
5	3	C1, C19, C33	Cap., Tantalum, 47µF, 35V, 10%, 7361	AVX, TAJV476K035RNJ
6	4	C2, C6, C21, C35	Cap., X7R, 0.1µF, 50V, 10%, 0805	AVX, 08055C104KAT2A
7	2	C3, C16	Cap., Tantalum, 330µF, 10V, 10%,7343	AVX, TPME337K010R0035
8	10	C4, C11, C17, C24, C30, C36, C39, C41, C43, C44	Cap., X5R, 0.1µF, 10V, 10%, 0402	AVX, 0402ZD104KAT2A
9	4	C5, C12, C18, C31	Cap., X5R, 1µF, 10V, 10%, 0402	AVX, 0402ZD105KAT2A
10	1	C7	Cap., Tantalum, 47µF, 20V, 10%, 7343	AVX, TAJD476K020RNJ
11	2	C8, C15	Cap., X7R, 470pF, 50V, 10%, 0402	AVX, 04025C471KAT2A
12	3	C23, C34, C45	Cap., X7R, 0.01µF, 16V, 10%, 0402	AVX, 0402YC103KAT2A
13	0	C25, C28	Opt., 0402	
14	5	C26, C29, C37, C38, C42	Cap., NPO, 100pF, 16V, 10%, 0402	AVX, 0402YA101KAT2A
15	1	D1	LED, RED	Panasonic, LN1251CTR
16	10	E3, E6, E11-E18	Turret, Testpoint, 2501	Mill-Max, 2501-2-00-80-00-00-07-0
17	1	JP1	Headers, 3 Pins, 2mm Ctrs.	Samtec, TMM-103-02-L-S
18	1	XJP1	Shunt, 2mm Ctrs.	Samtec, 2SN-BK-G
19	5	J1, J2, J5, J6, J7	Con., SMA 50Ω Edge-Launch	E. F. Johnson, 142-0701-851
20	0	J3, J4	Con., SMA 50Ω Straight Mount	Opt.
21	1	J8	Con., Header, 14 Pin, 2mm	Molex, 87831-1420
22	4	J9, J10, J11, J12	Jack, Banana	Keystone, 575-4
23	0	L1	Opt., 0402	
24	2	L2, L3	Ind., Wirebound, 68nH, ±5%, 0402	Coilcraft, 0402HPH-68NXJL
25	1	RZ_P	Res., Chip, 806, 1/10W, 1%, 0603	Vishay, CRCW0603806RFKEA
26	5	R1, R2, R25, R26, R27	Res., Chip, 4.99k, 1/16W, 1%, 0402	Vishay, CRCW04024K99FKED
27	1	R4	Res., Chip, 330, 1/16W, 1%, 0402	Vishay, CRCW0402330RFKED
28	1	R5	Res., Chip, 51.1, 1/16W, 1%, 0402	Vishay, CRCW040251R1FKED
29	4	R7, R8, R18, R19	Res., Chip, 200k, 1/16W, 1%, 0402	Vishay, CRCW0402200KFKED
30	4	R9, R10, R14, R16	Res., Chip, 0Ω, 0603	Vishay, CRCW06030000Z0EA
31	3	R12, R21, R22	Res., Chip, 100, 1/16W, 1%, 0402	Vishay, CRCW0402100RFKED
32	0	R13, R15, R17, RZ_A	Opt., 0603	
33	0	R23, R24	Res., Chip, 0402, Opt.	
34	1	U1	I.C. LTC6945IUFD, QFN28UFD	Linear Technology Corp., LTC6945IUFD
35	1	U2	Low Noise Amp, SO-8	Linear Technology Corp., LT1678CS8#PBF
36	1	U3 (1 Reel + 1 Tape, PbF)	Voltage Controlled Oscillator – VC0	Crystek, CVCO55CL-0902-0928
37	0	U4	Crystal Oscillator, Opt.	
38	2	U5, U6	I.C., Dual Buffer, SC-70 6-Lead	Fairchild Semi., NC7WZ17P6X
39	1	U7	I.C., Dual Transceiver, SC-70 6-Lead	NXP, 74LVC1T45GW
40	1	U8	I.C., Serial EEPROM, TSSOP-8	Mircochip, 24LC24A-I/ST
41	4	4 Corners	Standoff, Nylon, 0.50, 1/2"	Keystone, 8833 (Snap On)
42	2		Stencils (Top and Bottom)	Stencil, DC1649A-4

SCHEMATIC DIAGRAM

SCHEMATIC DIAGRAM

Note: The buffers shown on sheet 2 of 2 of the schematic are used to protect the LTC6945 when communicating to it starts before powering it up. There is no need for such circuitry if the SPI bus is not active before powering up the LTC6945. The EEPROM is for identification and is not needed to program the LTC6945.

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LAYOUT TOP LAYER

The top metal layer of DC1649A is shown here as an example of good PCB layout for the LTC6945.
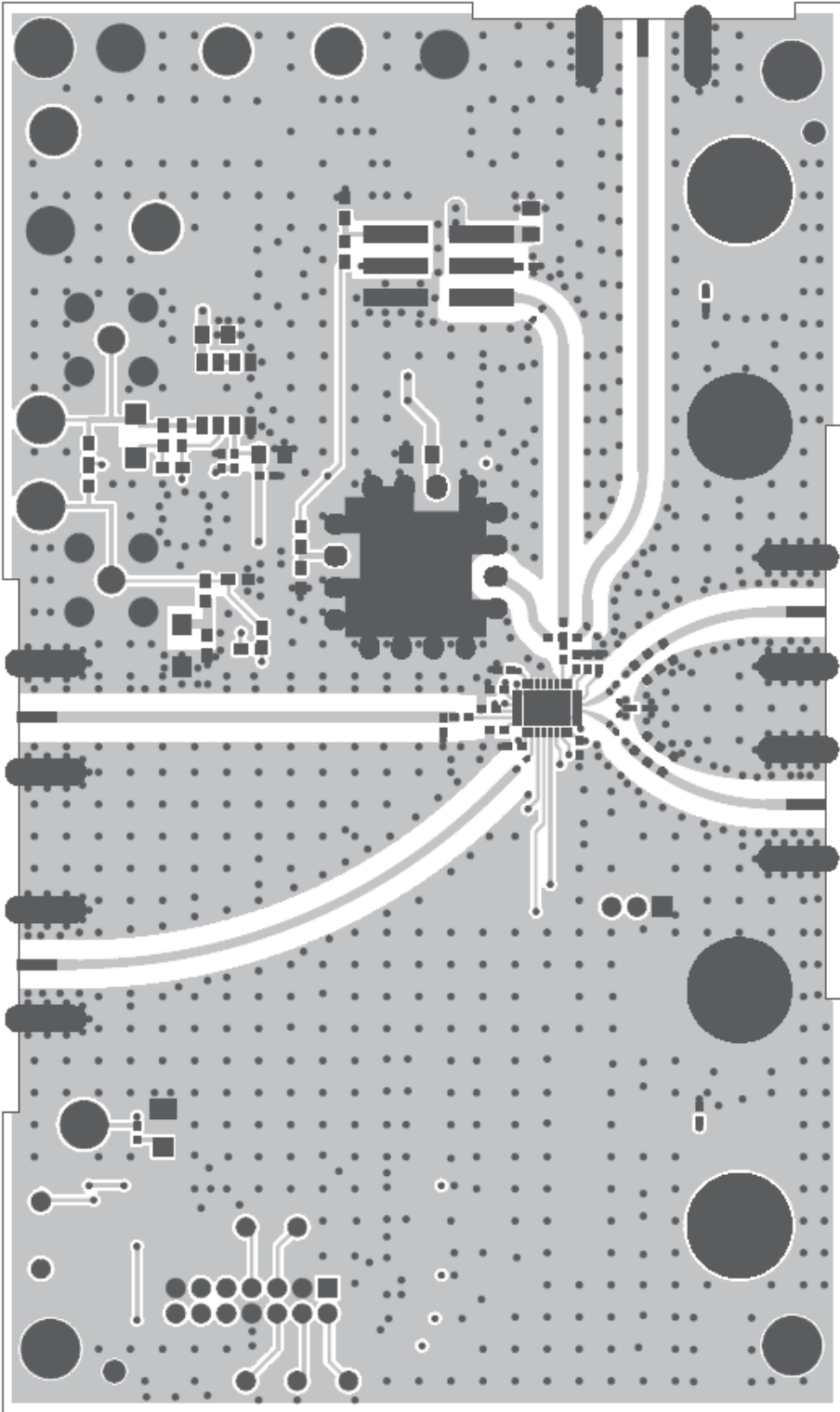
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