

LTC6430-15

400MHz to 1000MHz Differential ADC Driver/IF Amplifier

DESCRIPTION

Demonstration circuit [1774A-B](#) is a differential ADC driver/IF amplifier featuring the [LTC®6430-15](#). It is part of the DC1774A demo board family supporting the LTC643X-YY amplifier series. The DC1774A-B is optimized for a frequency range of 400MHz to 1000MHz and utilizes a minimum of passive external components to configure the amplifier for this application.

Because the LTC6430-15 has 100Ω differential input and output impedance, the demo circuit uses transformers

to convert the impedance to 50Ω single-ended so that it can be easily evaluated with commercially available RF test equipment.

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

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BLOCK DIAGRAM

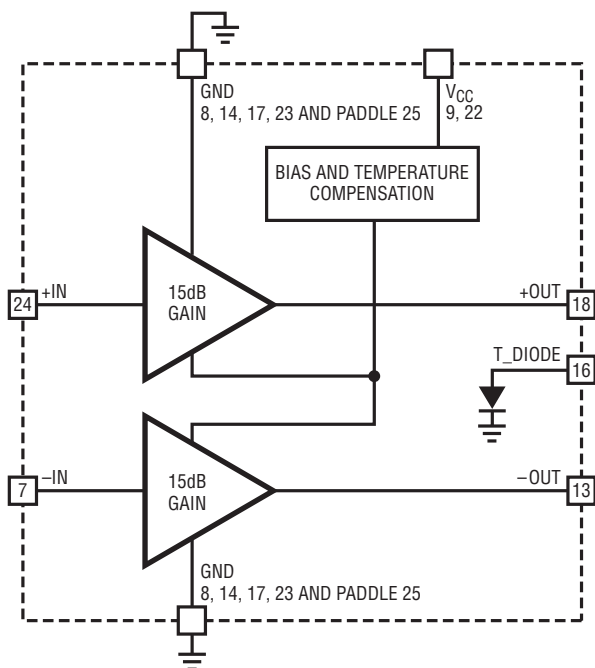


Figure 1. LTC6430-15 Block Diagram

DEMO MANUAL DC1774A-B

PERFORMANCE SUMMARY $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$

Table 1. Typical Demo Board Performance Summary

SYMBOL	PARAMETER	CONDITIONS	VALUE/UNIT
Power Supply			
V_{CC}	Operating Supply Range	All V_{CC} Pins Plus OUT Pins	4.75 to 5.25V
I_{CC}	Current Consumption	Total Current	160mA

FREQUENCY (MHz)	POWER GAIN $ S_{21} $ (dB)	OUTPUT THIRD ORDER INTERCEPT POINT (NOTE 1) OIP3 (dBm)	OUTPUT THIRD ORDER INTERMODULATION (NOTE 1) OIM3 (dBm)	SECOND HARMONIC DISTORTION (NOTE 2) HD2 (dBc)	THIRD HARMONIC DISTORTION (NOTE 2) HD3 (dBc)	OUTPUT 1dB COMPRESSION POINT P1dB (dBm)	NOISE FIGURE (NOTE 3) NF (dB)
400	14.8	46.5	-89.0	-71.2	-81.2	22.9	3.8
500	14.6	46.6	-89.3	-80.3	-76.1	23.0	4.0
600	14.5	46.2	-88.3	-67.4	-73.2	22.7	4.2
700	14.4	45.2	-86.5	-64.7	-68.1 (Note 4)	22.4	4.3
800	14.2	43.0	-82.0	-61.6	-70.6 (Note 4)	22.0	4.7
900	13.9	43.3	-82.6	-65.0	-67.7 (Note 4)	21.7	4.7
1000	13.6	43.1	-82.1	-70.6 (Note 4)	-64.5 (Note 4)	21.5	4.8

All figures are referenced to J7 (input port) and J8 (output port).

Note 1: 2-tone test condition: output power level = 2dBm/tone; tone spacing = 1MHz.

Note 2: Single-tone test condition: output power level = 8dBm.

Note 3: Small-signal noise figure.

Note 4: Out of input and output transformers working frequency range.

OPERATION

The demo circuit 1774A-B is a highly linear fixed-gain amplifier. The LTC6430-15 is internally matched to a 100 Ω differential source and a load impedance from 20MHz to 1300MHz. Due to the unpopularity of 100 Ω differential test equipment, transformers have been added to convert impedance from differential 100 Ω to single-ended 50 Ω for the input and the output ports. The frequency range of the circuit is limited by the balun transformers. Hence, this demo board works best with a frequency range from 400MHz to 1000MHz. Figure 2 shows the performance of the demo board.

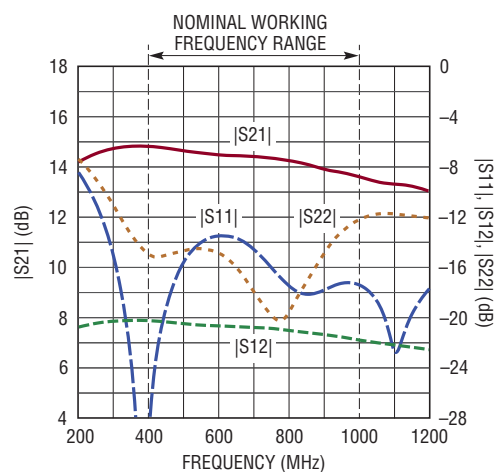


Figure 2. Demo Board DC1774A-B S-Parameters

An optional stability network has been added. It consists of parallel 62pF (C8 and C9) and 348Ω (R1 and R2) to ensure low frequency stability.

Table 2. DC1774A-B Board I/O Descriptions

CONNECTOR	FUNCTION
J7 (+IN)	Single-Ended Input. Impedance-Matched to 50Ω. Drive from a 50Ω Network Analyzer or Signal Source.
J8 (–OUT)	Single-Ended Output. Impedance-Matched to 50Ω. Drive from a 50Ω Network Analyzer or Spectrum Analyzer.
E3 or J11 (VCC)	Positive Supply Voltage Source.
E6 or J18 (GND)	Negative Supply Ground.

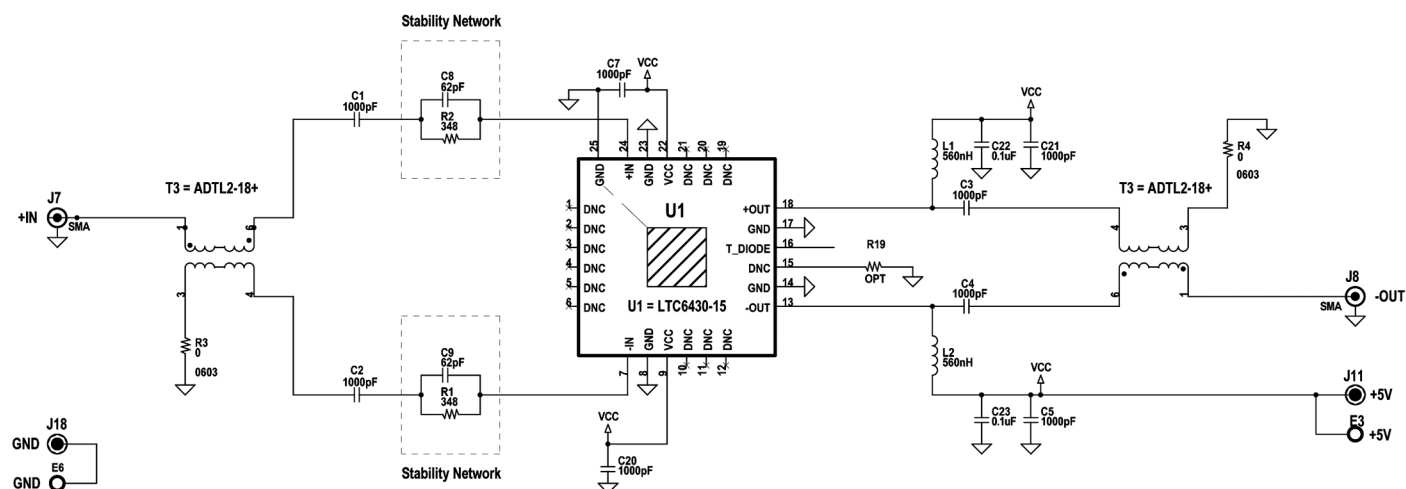


Figure 3. Simplified Demo Board DC1774A-B Schematic

ADDITIONAL INFORMATION

The particular element values shown in the demo board schematic are chosen for wide bandwidth operation. Depending on the desired frequency, performance may be improved by the proper selection of these supporting components.

As with any RF device, minimizing ground inductance is critical. Care should be taken with the board layout because of the exposed pad packages. The maximum number of minimum diameter via holes should be placed underneath the exposed pad. This will ensure good RF ground and low thermal impedance. Maximizing the copper ground plane will also improve heat spreading and low inductance. It is a good idea to cover the via holes with solder mask on the back side of the PCB to prevent solder from wicking away from the critical PCB to the exposed pad interface.

The DC1774A-B has a nominal working frequency range from 400MHz to 1000MHz. It is not intended for operation down to DC. The lower frequency cutoff is limited by on-chip matching elements.

The generic LTC643X-YY amplifier series demo PCB is shown in the Schematic Diagram of Figure 6. Hence, the board can be modified for multiple demo board versions. For example, both the DC1774A-A and DC1774A-B demo boards have a differential driver at U1; therefore, the board is using transformers to transform from differential to single-ended input and output. Likewise, the DC1774A-C is a single-ended demo board; consequently, it uses the LTC6431-15 for single-ended input and output.

SETUP AND TESTING SIGNAL SOURCES

The LTC6430-15 is an amplifier with high linearity performance; therefore, output intermodulation products are very low. For this reason, it drives most test equipment and test setups to their limits. Consequently, accurate measurement of the third order intercept point for a low distortion IC such as the LTC6430-15 requires certain precautions to be observed in the test setup and testing procedure.

Setup Signal Sources

Figure 5 shows a proposed IP3 test setup. This setup has low phase noise, good reverse isolation, high dynamic range, sufficient harmonic filtering and wideband impedance matching. The setup is outlined here:

1. High performance signal generators 1 and 2, (HP8644A) should be used in the setup. These suggested generators have low harmonic distortion and very low phase noise.
2. High linearity amplifiers to improve isolation. They prevent the two signal generators from crosstalking with each other and provide higher output power.
3. A lowpass filter to suppress harmonic content from interfering with the test signal.
4. The signal combiner (from Mini-Circuits ADP-2-9), combines the two isolated input signals. This combiner has a typical isolation of 27dB. For better VSWR and isolation, use the H-9 signal combiner from MA/COM which features >40dB isolation and a wider frequency range. Passive devices (e.g., combiners) with magnetic elements can contribute nonlinearity to the signal chain and should be used cautiously.
5. The attenuator pads, on all three ports of the signal combiner, will support further isolation of the two input signal sources. They will reduce reflection and promote maximum power transfer with wideband impedance matching.

Testing Signal Sources

The testing signal should be evaluated and optimized before it is used for measurements. The following outlines the necessary steps to achieve optimization.

- a. Apply two independent signals f1 and f2 from signal generator 1 and signal generator 2 at 400MHz and 401MHz while setting amplitude = -13dBm per tone at the combined output.

ADDITIONAL INFORMATION

- b. Connect the combined signal directly to the spectrum analyzer (without the DUT).
- c. Adjust the spectrum analyzer for the maximum possible resolution of the Intermodulation products amplitude in dBc relative to the main tone power. A narrower resolution bandwidth will take a longer time to sweep. Optimize the dynamic range of the spectrum analyzer by adjusting input attenuation. First increase the spectrum analyzer input attenuation (normally in steps of 5dB or 10dB). If the IMD product levels decrease when the input attenuation is increased, then the input power level was too high for the spectrum analyzer to make a valid measurement. In other words, the spectrum analyzer's 1st mixer was overloaded and produced its own IMD products. If the IMD reading holds constant with increased input attenuation, then a sufficient amount of attenuation is present. Adding too much attenuation will raise the noise floor and bury the intended IMD signal. Therefore, select just enough attenuation to achieve a stable and valid measurement.
- d. In order to achieve a valid measurement result, the test system must have lower distortion than the DUT intermodulation. For example, to measure a 47dBm OIP3, the measured intermodulation products will be -90dBc below the -13dBm per tone input level and the test system must have intermodulation products approximately -96dBc or better. For best results, the IMD or noise floor should be at least -100dBc before connecting the DUT.

Testing the DUT

At this point, the input level has been established at -13dBm per tone, and the input IMD from the test setup is well suppressed at -96dBm max. Furthermore, the SA is set up to measure very low level IMD components.

- a. Insert the DUT and output attenuator into the setup, inline between the signal source and SA. The output attenuator should match the DUT gain.
- b. Fine-tune the signal generator levels by a small amount if necessary (<1dB), to keep output power at 2.0dBm per tone at the amplifier output.
- c. Measure output IMD level using the same optimized setup as previous. Based on the output power level of 2dBm per tone, and knowing the IMD level, OIP3 can be calculated.

QUICK START PROCEDURE

Demo circuit 1774A-B can be set up to evaluate the performance of the LTC6430-15. Refer to Figures 4 and 5 for proper equipment connections and follow the procedure below:

Single-Tone Measurement

Connect all test equipment as suggested in Figure 4.

1. The power labels of 5V and GND directly correspond to the power supply. Typical current consumption of the LTC6430-15 is about 160mA.
2. Apply an input signal to J7. A low distortion, low noise signal source with an external high order lowpass filter will yield the best performance. The input C.W. signal is -10dBm .
3. Observe the output via J8. The measured power at the analyzer should be about 5dBm .

Two-Tone Measurement

Connect all test equipment as suggested in Figure 5.

1. The power labels of 5V and GND directly correspond to the power supply. Typical current consumption of the LTC6430-15 is about 160mA.
2. Apply two independent signals f1 and f2 from SG1 and SG2 at 400MHz and 401MHz respectively.
3. Monitor the output tone level on the spectrum analyzer. Adjust signal generator levels such that output power measures 2dBm/tone at the amplifier output J8, after correcting for external cable losses and attenuations.
4. Change the spectrum analyzer's center frequency and observe the two IM3 tones at 1MHz below and above the input frequencies. The frequencies of IM3_LOW, and IM3_HIGH are 399MHz and 402MHz, respectively.

For this setup, the Rohde & Schwarz FSEM30 spectrum analyzer was used. This SA has a typical 20dBm third order intercept point (TOI). The Rohde & Schwarz FSU can also be used. The system as described can measure OIP3 up to 50dBm .

QUICK START PROCEDURE

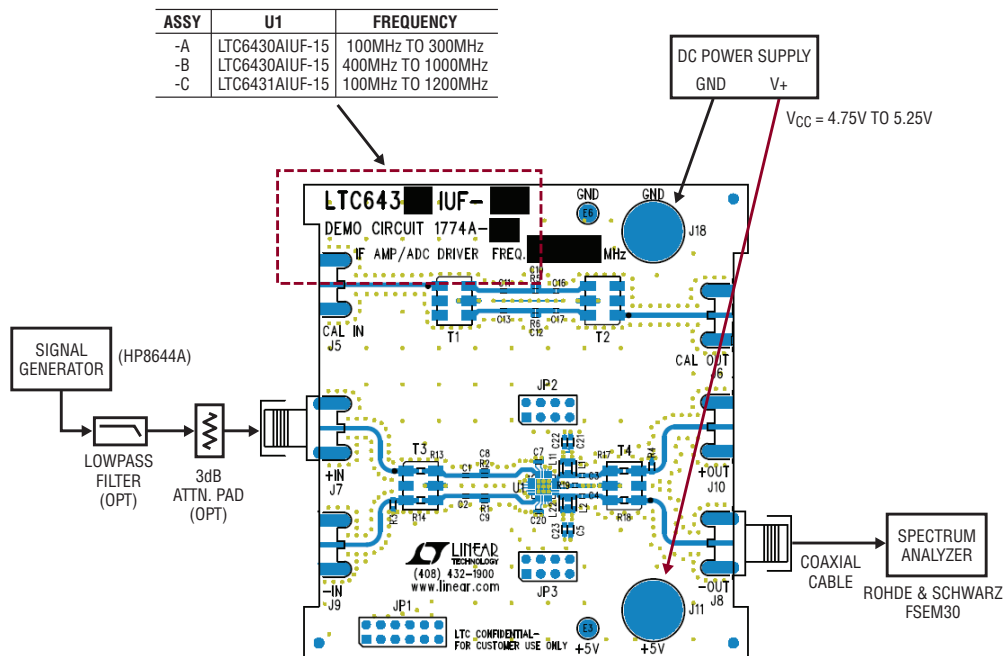


Figure 4. Proper Equipment Setup for Gain and Single-Tone Measurement

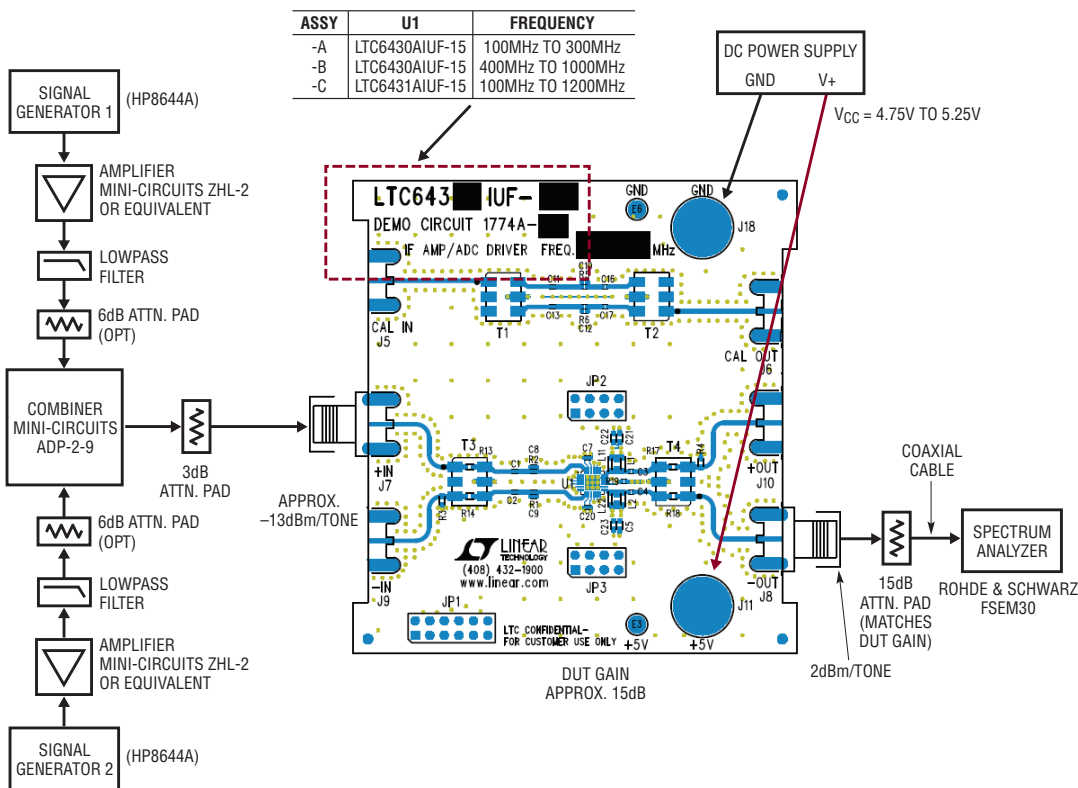


Figure 5. Proper Equipment Setup for IP3 Measurement

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	4	C1, C3, C7, C20	CAP., X7R, 1000pF, 50V 5%, 0402	AVX, 04025C102JAT2A
2	1	C21	CAP., X7R, 1000pF, 50V 5%, 0603	AVX, 06035C102JAT2A
3	1	C8	CAP., COG, 62pF, 16V 2%, 0402	AVX, 0402YA620GAT2A
4	0	C10, C12	CAP., COG, 62pF, 16V 2%, 0402	OPT
5	0	C11, C13, C16-C19	CAP., X7R, 1000pF, 5%, 0402	OPT
6	1	C22	CAP., X5R, 0.1µF, 10V, 10%, 0603	AVX, 0603ZD104KAT2A
7	2	E3, E6	TESTPOINT, TURRET, 0.064"	MILL-MAX, 2308-2-00-80-00-00-07-0
8	0	JP1	HEADER, 2X6, 0.1"	OPT
9	0	JP2, JP3	HEADER, 2X4, 0.1"	OPT
10	0	J5, J6	CONN., SMA 50Ω EDGE-MOUNTED	OPT
11	1	J7	CONN., SMA 50Ω EDGE-MOUNTED	JOHNSON, 142-0701-851
12	0	J9	CONN., SMA 50Ω EDGE-MOUNTED	OPT
13	2	J11, J18	JACK, BANANA	KEYSTONE, 575-4
14	1	L1	INDUCTOR, CHIP, 560nH, 5%, 0603LS-1608	COILCRAFT, 0603LS-561XJLB
15	0	L11, L22	INDUCTOR, CHIP, 1008LS-2520	OPT
16	1	R2	RES., CHIP, 348Ω, 1%, 0402	YAGEO, RC0402FR-07348RL
17	0	R5, R6	RES., CHIP, 348Ω, 1%, 0402	OPT
18	0	R19	RES., CHIP, 0Ω, 5%, 0402	YAGEO, RC0402JR-070RL
1	1	DC1774A-2	GENERAL BOM	
2	2	C2, C4	CAP., X7R, 1000pF, 50V 5%, 0402	AVX, 04025C102JAT2A
3	1	C5	CAP., X7R, 1000pF, 50V 5%, 0603	AVX, 06035C102JAT2A
4	1	C9	CAP., COG, 62pF, 16V 2%, 0402	AVX, 0402YA620GAT2A
5	0	C14, C15	CAP., X7R, 1000pF, 25V 5%, 0402	AVX, 04023C102JAT2A
6	1	C23	CAP., X5R, 0.1µF, 10V, 10%, 0603	AVX, 0603ZD104KAT2A
7	1	L2	INDUCTOR, CHIP, 560nH, 5%, 0603LS-1608	COILCRAFT, 0603LS-561XJLB
8	1	J8	CONN., SMA 50Ω EDGE-MOUNTED	JOHNSON, 142-0701-851
9	0	J10	CONN., SMA 50Ω EDGE-MOUNTED	OPT
10	1	R1	RES., CHIP, 348Ω, 1%, 0402	YAGEO, RC0402FR-07348RL
11	2	R3, R4	RES., CHIP, 0Ω, 1/16W, 5%, 0603	YAGEO, RC0603JR-070RL
12	0	R13, R14, R17, R18	RES., CHIP, 0Ω, 1/16W, 5%, 0603	OPT
13	0	T1, T2	XFMR, MINI-CIRCUITS, ADTL2-18+	OPT
14	2	T3, T4	XFMR, 2:1	MINI CIRCUITS, ADTL2-18+
15	1	U1	IC, IF AMP., QFN24UF-4X4	LINEAR TECH., LTC6430AIUF-15



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Mailing Address:

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035

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