

LTC6430-15

100MHz to 300MHz Differential ADC Driver/IF Amplifier

DESCRIPTION

Demonstration circuit 1774A-A 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-A is optimized for a frequency range of 100MHz to 300MHz 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 allowing easy evaluation with commercially available RF test equipment.

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

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PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$

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

| Frequency (MHz) | Power Gain $ S_{21} $ (dB) | Output Third-Order Intercept Point ¹ OIP3 (dBm) | Output Third-Order Intermodulation ¹ OIM3 (dBc) | Second Harmonic Distortion ² HD2 (dBc) | Third Harmonic Distortion ² HD3 (dBc) | Output 1dB Compression Point P1dB (dBm) | Noise Figure ³ NF (dB) |
|--------------------|----------------------------------|--|--|---|---|---|---|
| 50 | 13.1 | 47.1 | -90.2 | -83.3 | -93.1 | 21.8 | 5.2 |
| 100 | 14.5 | 47.3 | -90.5 | -84.6 | -95.3 | 22.6 | 4.1 |
| 200 | 14.5 | 47.2 | -90.3 | -86.6 | -90.9 | 22.2 | 4.0 |
| 240 | 14.2 | 50.0 | -96.0 | -83.8 ⁽⁴⁾ | -85.2 ⁽⁴⁾ | 22.2 | 4.1 |
| 300 | 13.6 | 47.0 | -90.0 | -73.6 ⁽⁴⁾ | -83.4 ⁽⁴⁾ | 22.0 | 4.4 |
| 400 | 12.2 | 46.4 | -88.8 | -56.1 ⁽⁴⁾ | -85.0 ⁽⁴⁾ | 21.3 | 5.1 |

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

Note 1: Two-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: Performance degraded due to transformers' being out of working frequency range.

BLOCK DIAGRAM

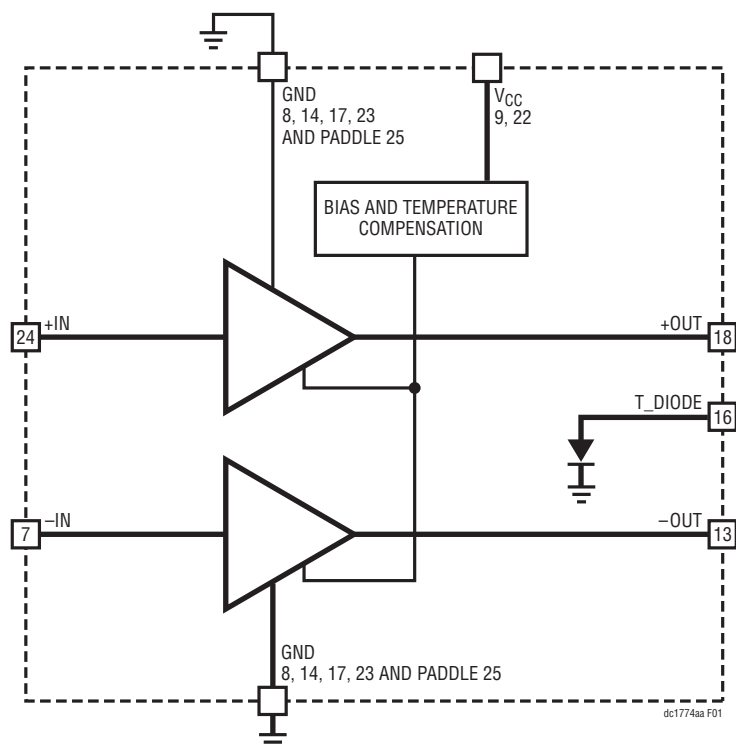


Figure 1. LTC6430-15 Device Block Diagram

OPERATION

Demo Circuit 1774A-A is a highly linear fixed-gain amplifier. The LTC6430-15 is internally matched to a 100Ω differential source and load impedance from 20MHz to 1300MHz. Due to the unpopularity of 100Ω differential test equipment, transformers have been added to convert impedance from differential 100Ω to single-ended 50Ω 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 100MHz to 300MHz. Figure 2 shows the performance of the demo board.

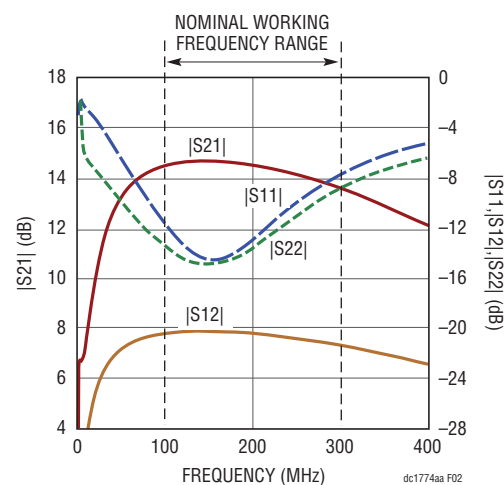


Figure 2. Demo Board DC1774A-A S-Parameters

OPERATION

Figure 3 shows the simplified demo circuit schematic. It requires a minimum of passive supporting components. The 2:1 transformers convert the differential to single-ended 50Ω for compatibility with most test equipment. The input and output DC-blocking capacitors (C1, C2, C3 and C4) are required because this device is internally biased for optimal operation. The frequency appropriate choke (L1 and L2) and the decoupling capacitors (C5, C21, C22 and C23) provide bias to the RF±OUT nodes. Only a single 5V supply is necessary for V_{CC} pins on the device.

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

Table 1 shows the function of each input and output on the board.

Table 1. DC1774A-A 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 (V _{CC}) | Positive Supply Voltage Source. |
| E6 or J18 (GND) | Negative Supply Ground. |

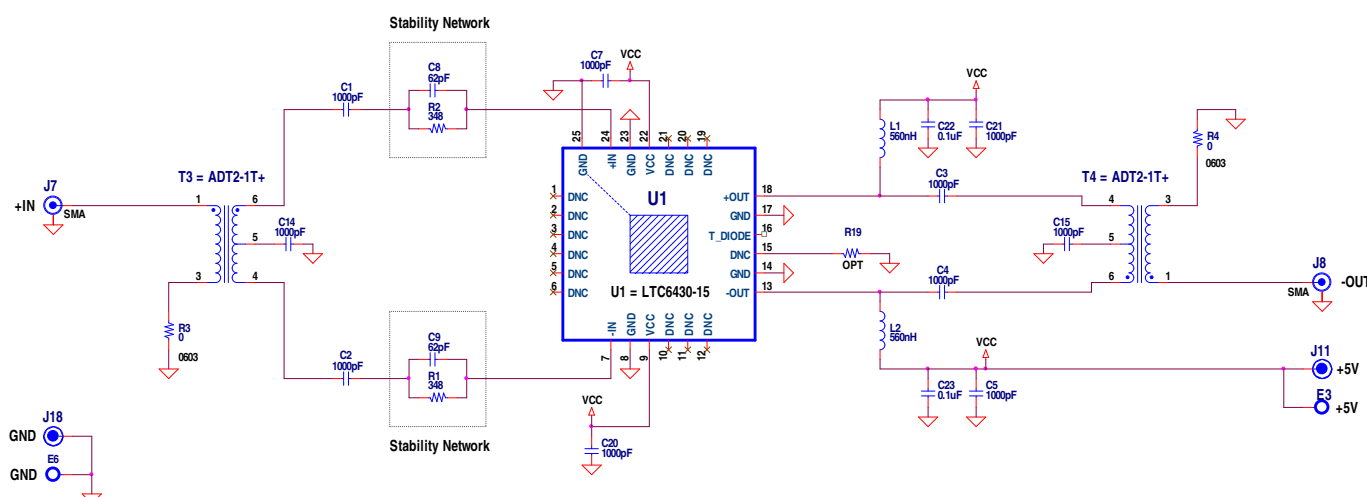


Figure 3. Simplified Demo Board DC1774A-A Schematic

OPERATION

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 these exposed pad packages. The maximum number of minimum diameter vias 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-A has a nominal working frequency range from 100MHz to 300MHz. It is not intended for operation down to DC. The lower frequency cutoff is limited by on-chip matching elements.

Figure 6 shows the generic PCB schematic for the LTC643X-YY amplifier series. The board can be modified for multiple demo board versions. For example, both DC1774A-A and DC1774A-B demo boards have a differential amplifier 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; 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:

- a. 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.
- b. High linearity amplifiers to improve isolation. They prevent the two signal generators from crosstalking with each other and provide higher output power.
- c. A lowpass filter to suppress harmonic contents from interfering with the test signal.
- d. 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 M/A-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.
- e. 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.

SETUP AND TESTING SIGNAL SOURCES

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:

- Apply two independent signals, f1 and f2, from signal generator 1 and signal generator 2 at 240MHz and 241MHz while setting amplitude = -12dBm per tone at the combined output.
- Connect the combined signal directly to the spectrum analyzer (without the DUT).
- 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 1st mixer was overloaded and producing its own IMD products. If the IMD reading holds constant with increased input attenuation, then a sufficient amount of attenuation was 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.

- 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 -12dBm 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 -12dBm per tone, and the input IMD from the test setup is well suppressed at -96dBm max. Furthermore, the spectrum analyzer is set up to measure very low level IMD components.

- Insert the DUT and output attenuator into the setup, inline between the signal source and the spectrum analyzer. The output attenuator should match the DUT gain.
- Fine tune the signal generator levels by a small amount if necessary (<1dB), to keep output power at 2dBm per tone at the amplifier output.
- Measure the 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-A can be set up to evaluate the performance of the LTC6430-15. Refer to Figures 4 and 5 for proper equipment connections and follow this procedure:

Single-Tone Measurement:

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 signal is -10dBm. The input is impedance-matched to 50Ω.

3. Observe the output via J8. The measured power at the analyzer should be about 4dBm. The output is impedance-matched to 50Ω, suitable for the input of a network or spectrum analyzer.

Two-Tone Measurement:

Connect all test equipment as suggested in Figure 8.

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 240MHz and 241MHz, respectively.

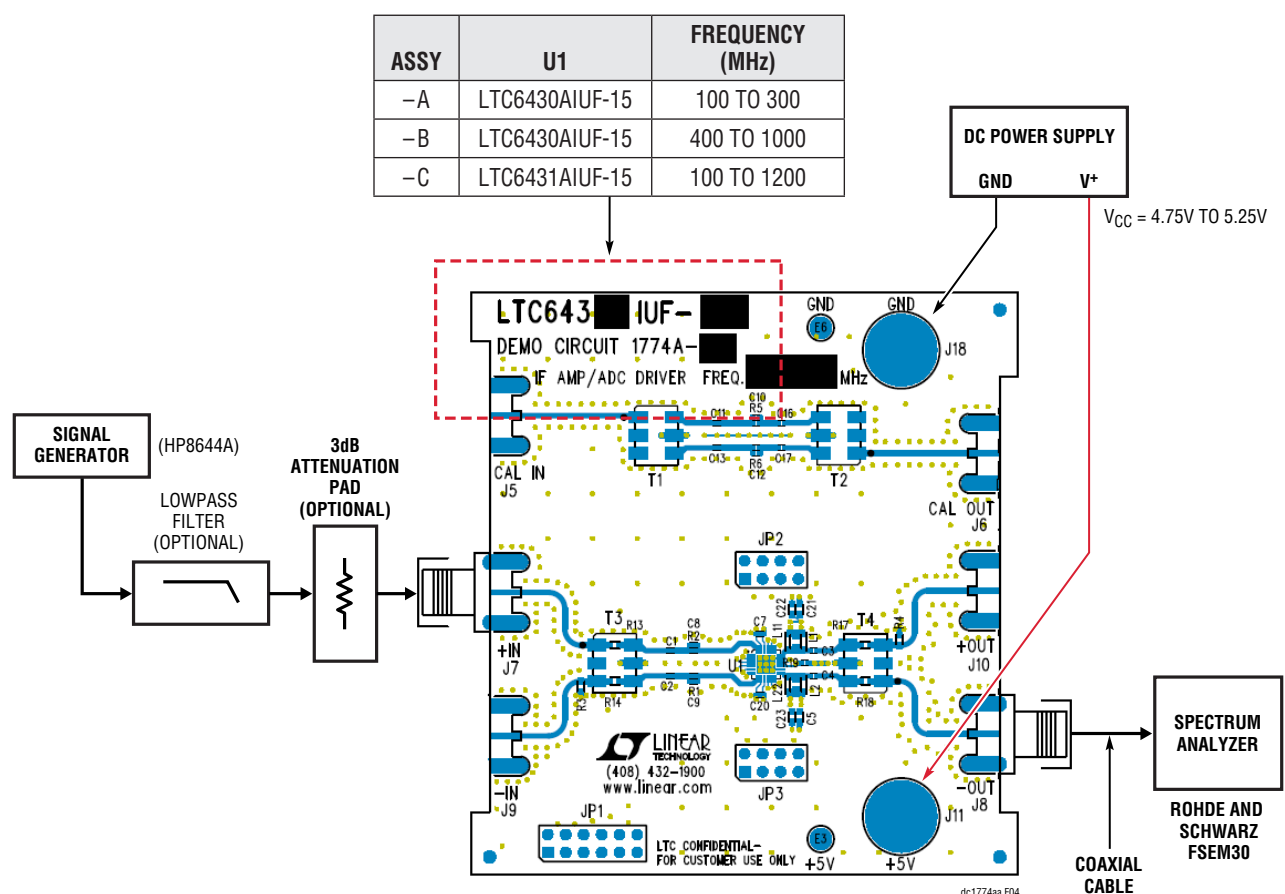


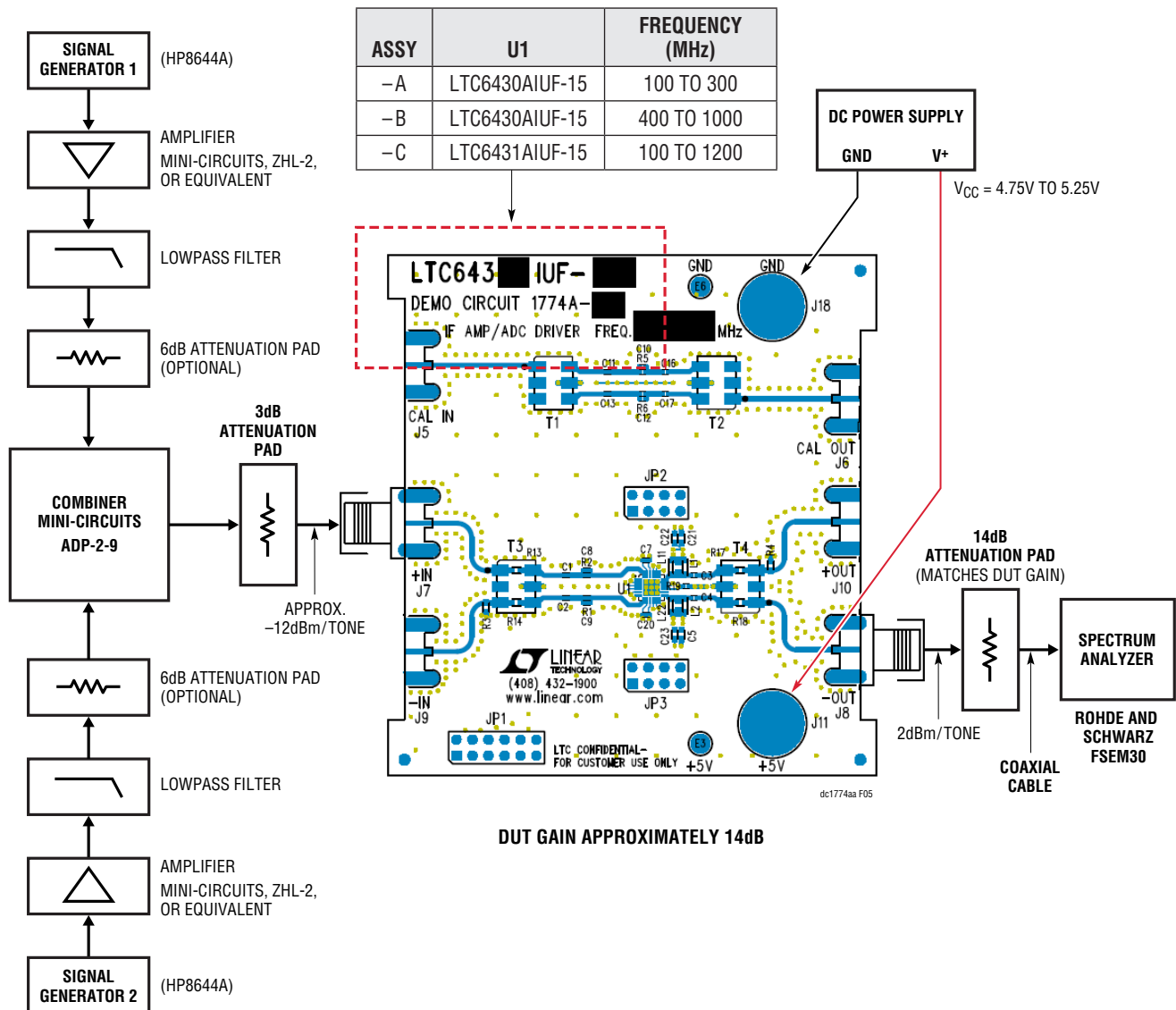
Figure 4. Proper Equipment Setup for Gain and Single-Tone Measurement

QUICK START PROCEDURE

3. Monitor the output tone level on the spectrum analyzer. Adjust signal generator levels such that the 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 239MHz and 242MHz, respectively.

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



DEMO MANUAL DC1774A-A

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|-----|--------------------|--|-----------------------------------|
| DC1774A-2 Required Circuit Components | | | | |
| 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, 2×6, 0.1" | OPT |
| 9 | 0 | JP2, JP3 | HEADER, 2×4, 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, 348, 1%, 0402 | YAGEO, RC0402FR-07348RL |
| 17 | 0 | R5, R6 | RES., CHIP, 348, 1%, 0402 | OPT |
| 18 | 0 | R19 | RES., CHIP, 0Ω, 5%, 0402 | YAGEO, RC0402JR-070RL |
| DC1774A2-A Required Circuit Components | | | | |
| 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 | 2 | 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, 348, 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, ADT2-1T+ | OPT |
| 14 | 2 | T3, T4 | XFMR, 2:1 | MINI CIRCUITS, ADT2-1T+ |
| 15 | 1 | U1 | IC, IF AMP., QFN24UF-4×4 | LINEAR TECHNOLOGY, LTC6430AIUF-15 |

SCHEMATIC DIAGRAM

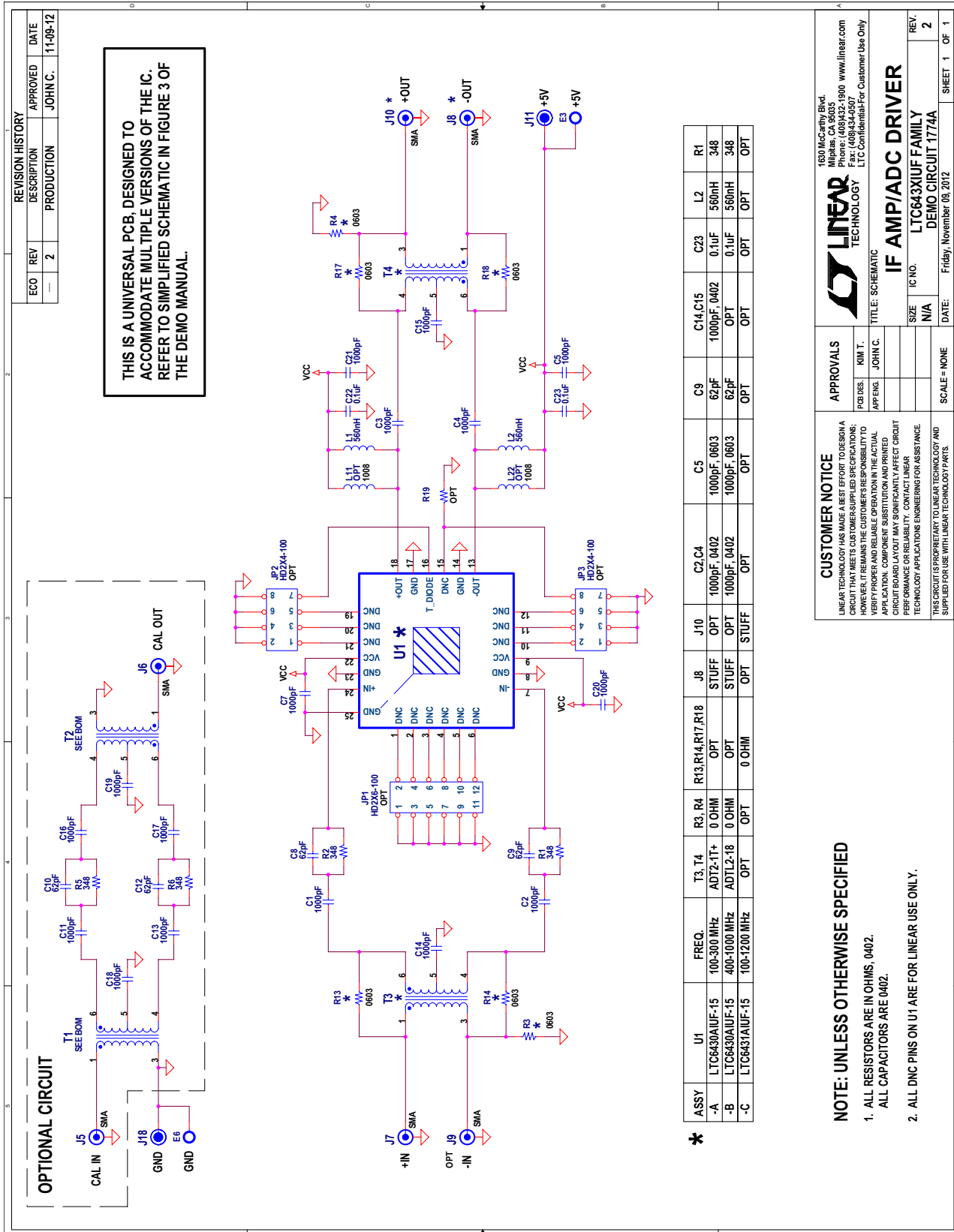


Figure 6. DC1774A RF/IF AMP/ADC Driver

DEMO MANUAL DC1774A-A

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