

# LTC6430-20

## 50MHz TO 1000MHz

### 75Ω INPUT/OUTPUT CATV AMPLIFIER

## DESCRIPTION

Demonstration circuit 2078A is a 75Ω input and 75Ω output push-pull CATV amplifier featuring the [LTC®6430-20](#). The LTC6430-20 has a power gain of 20.8dB and is part of the LTC6430-YY amplifier series.

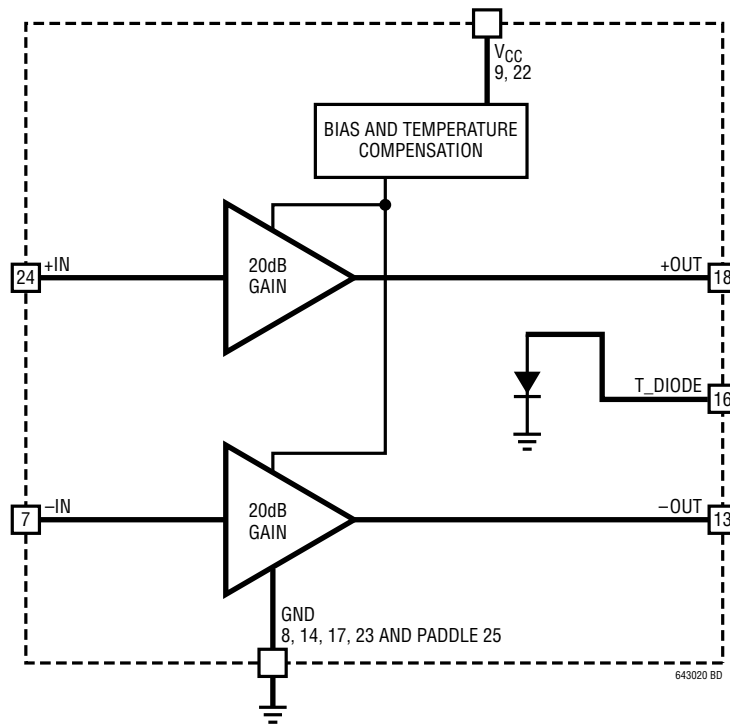
The DC2078A demo board is optimized for the frequency range from 50MHz to 1000MHz. It incorporates a minimum of passive support components to configure the

amplifier for the CATV applications with 75Ω input and output impedance.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2078A>**

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## LTC6430-20 BLOCK DIAGRAM



# DEMO MANUAL DC2078A

## 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
<b>Power Supply</b>			
$V_{CC}$	Operating Supply Range	All $V_{CC}$ Pins Plus $\pm\text{OUT}$	4.75V to 5.25V
$I_{CC}$	Current Consumption	Total Current	170mA

FREQUENCY (MHz)	POWER GAIN  S21	OUTPUT THIRD-ORDER INTERCEPT POINT <sup>1</sup> OIP3	OUTPUT THIRD-ORDER INTER-MODULATION <sup>1</sup> OIM3	SECOND HARMONIC DISTORTION <sup>2</sup> HD2	THIRD HARMONIC DISTORTION <sup>2</sup> HD3	OUTPUT 1DB COMPRESSION POINT P1DB	NOISE FIGURE <sup>3</sup> NF
50	19.1	46.5	-91.0	-86.4	-87.6	22.3	3.5
100	19.1	46.7	-91.4	-86.6	-82.7	22.6	3.5
200	19.1	45.6	-89.3	-82.2	-79.0	22.8	3.5
240	19.1	44.5	-86.9	-80.8	-78.2	22.9	3.4
300	19.1	43.7	-85.4	-73.4	-72.9	23.4	3.4
400	19.3	44.1	-86.2	-66.6	-73.2	24.0	3.4
500	19.4	46.8	-91.6	-62.6		24.2	3.5
600	19.2	47.0	-92.0			24.3	3.8
700	18.8	46.3	-90.6			23.7	4.3
800	18.5	43.7	-85.4			22.8	4.7
900	18.4	41.9	-81.9			22.5	5.0
1000	18.5	41.5	-81.0			22.7	5.0
<b>Units</b>	<b>dB</b>	<b>dBm</b>	<b>dBc</b>	<b>dBc</b>	<b>dBc</b>	<b>dBm</b>	<b>dB</b>

Notes: All figures are referenced to J1 (Input Port) and J4 (Output Port).

1. Two-tone test conditions: Output power level = +1dBm/tone, tone spacing = 1MHz.
2. Single-tone test conditions: Output power level = +6dBm.
3. Small-signal noise figure.

## OPERATION

Demo circuit 2078A is a high linearity, fixed gain amplifier. To configure the demo circuit 2078A for use in the 75Ω CATV environment, a transformer with 1:1.33 impedance ratio is added at the board's input and output. These transformers transform the differential 100Ω impedance of the LTC6430-20 to single-ended 75Ω impedance. The frequency range of the circuits is limited by the balun transformers. Hence, the demo board has a nominal working frequency range from 50MHz to 1000MHz. Figure 2 shows the S-parameters of demo board.

Demo circuit 2078A is shipped with 75Ω F-type connectors (J1 and J2) at both input and output. Depending on the user's preference, the board may also accept other connector types such as BNC or SMA. Please note that the use of substandard connectors can limit the usable bandwidth of the circuit.

The input and output transformers (T3 and T4) convert the differential signal to single-ended 75Ω signal for compatibility with the CATV environment, while preserving all the exceptional characteristics of the LTC6430-20. In addition, the balun's excellent phase balance and the second order linearity of the LTC6430-20 combine to further suppress second order products across the entire CATV band. Figure 3 shows the spurious products (in dBc) within the passband frequency 50MHz to 1000MHz. The output third-order intermodulation (OIM3) and the second harmonic distortion (HD2) are shown as a function of frequency.

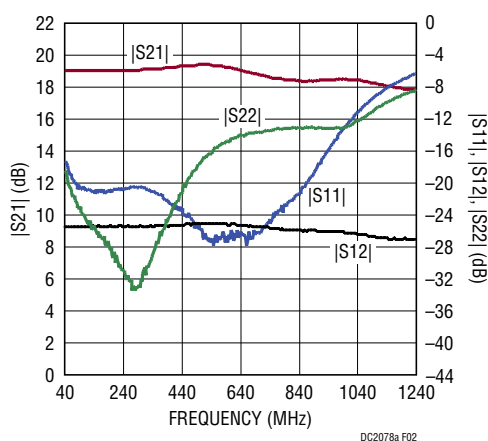
The input and output DC blocking capacitors (C1, C2, C7 and C8) are required because this device is internally biased for optimal operation.

Frequency appropriate chokes (L1 and L2) and the decoupling capacitors (C9, C10, C11 and C12) provide bias to the RF ±OUT nodes. Only a single 5V supply is necessary for the V<sub>CC</sub> pins on the device.

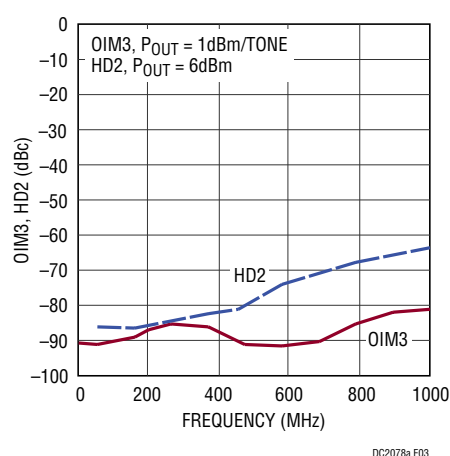
**Table 2. DC2078A Board I/O Descriptions**

CONNECTOR	FUNCTION
J1 (IN)	Single-Ended Input. Impedance Matched to 75Ω.
J2 (OUT)	Single-Ended Output. Impedance Matched to 75Ω.
E1 (VCC)	Positive Supply Voltage Source.
E2 (GND)	Negative Supply Ground.
E3 (T_DIODE)	The measured voltage will be an indicator of the chip junction temperature.

In this particular application circuit, the input stability networks (C3, C4, R1, R2) are not required since the LTC6430-20 is preceded by a low frequency termination from the balun transformer. In a wideband differential application where the bandwidth extends below 20MHz, the input stability network is suggested.



**Figure 2. Demo Board S-Parameters**



**Figure 3. OIM3 and HD2 vs Frequency**

## OPERATION

L3, L4, C19 and C20 are optional parts. They are for additional matching components when further optimization to a lower or wider frequency range applications is required.

Table 2 shows the function of each input and output on the board.

### Additional Information

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 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 lower the inductance to ground. 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 T\_DIODE Pin (Turret E3) can be forward biased to ground with 1mA of current. The measured voltage will be an indicator of the chip junction temperature (TJ).

Please note that a number of DNC pins are connected on the demo board. These connections are not necessary for normal operation, however, failure to float these pins may impair the operation of the device.

Table 3 shows the LTC643X-YY amplifier series and its associated demo boards. Each demo board lists the typical working frequency range and the input and output impedance of the amplifiers.

### Setup Signal Sources and Spectrum Analyzer

The LTC6430-20 is an amplifier with high linearity performance. Therefore, the output intermodulation products are very low. Even using high dynamic range test equipment, Third-Order Intercept (IP3) measurements can drive test setups to their limits. Consequently, accurate measurement of IP3 for a low distortion IC such as the LTC6430-20 requires certain precautions to be observed in the test setup as well as in the testing procedure.

**Table 3. The LTC643X-YY Amplifier Family and Corresponding Application Demo Boards**

DEMO BOARD NUMBER	FREQUENCY RANGE (MHz)	NOTES/APPLICATIONS	BOARD'S IN/OUT IMPEDANCE	AMPLIFIER	AMPLIFIER'S IMPEDANCE
DC1774A-A	50 to 350	Low Frequency	50Ω	LTC6430-15	Differential 100Ω
DC1774A-B	400 to 1000	Mid Frequency	50Ω	LTC6430-15	Differential 100Ω
DC1774A-C	100 to 1200	Wide Frequency	50Ω	LTC6431-15	Single-ended 50Ω
DC2032A	50 to 1000	Cable Infrastructure	75Ω	LTC6430-15	Differential 100Ω
DC2077A	100 to 1200	Wide Frequency	50Ω	LTC6431-20	Single-ended 50Ω
DC2153A	700 to 1700	High Frequency	50Ω	LTC6430-15	Differential 100Ω
DC2090A	50 to 1200	Power Doubler	50Ω	Dual LTC6430-15	Differential 50Ω
DC2076A-A	50 to 350	Low Frequency	50Ω	LTC6430-20	Differential 100Ω
DC2076A-B	350 to 1000	Mid Frequency	50Ω	LTC6430-20	Differential 100Ω
DC2078A	50 to 1000	Cable Infrastructure	75Ω	LTC6430-20	Differential 100Ω

## OPERATION

### Setup Signal Sources

Figure 4 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 below:

- a. High performance signal generators 1 and 2 (HP8644A) are used. These suggested generators have low harmonic distortion and very low phase noise.
- b. High linearity amplifiers are used to improve the reverse isolation. This prevents cross talk between the two signal generators and provides higher output power.
- c. A low pass filter is used to suppress the harmonic content from interfering with the test signal. Note that second order inputs can “mix” with the fundamental frequency to form intermodulation (IM) products of their own. We suggest filtering the harmonics to  $-50\text{dBc}$  or better.
- d. The signal combiner from Mini-Circuits (ADP-2-9) combines the two isolated input signals. This combiner has a typical isolation of  $27\text{dB}$ . For improved VSWR and isolation, the H-9 signal combiner from MA/COM is an alternative which features  $>40\text{dB}$  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 further support isolation of the two input signal sources. They also reduce reflections and promote maximum power transfer with wideband impedance matching.

### Setup the Spectrum Analyzer

- a. Adjust the spectrum analyzer for maximum possible resolution of the intermodulation products' amplitude in  $\text{dBc}$ . A narrower resolution bandwidth will take a longer time to sweep.
- b. Optimize the dynamic range of the spectrum analyzer by adjusting the input attenuation. First increase the spectrum analyzer's input attenuation (normally in steps of  $5\text{dB}$  or  $10\text{dB}$ ). If the IM product levels decrease when the input attenuation is increased, then the input power level is too high for the spectrum analyzer to make a valid measurement. Most likely, the spectrum analyzer's 1st mixer was overloaded and producing its own IM products. If the IM reading holds constant with increased input attenuation, then a sufficient amount of attenuation was present. Adding too much attenuation will bury the intended IM signal in the noise floor. Therefore, select just enough attenuation to achieve a stable and valid measurement.
- c. In order to achieve this valid measurement result, the test system must have lower total distortion than the DUT's intermodulation. For example, to measure a  $47\text{dBm}$  OIP3, the measured intermodulation products will be  $-92\text{dBc}$  below an  $-18\text{dBm}$ /tone input level and the test system must have intermodulation products approximately  $-98\text{dBc}$  or better. For best results, the IM products and noise floor should measure at least  $-102\text{dBc}$  before connecting the DUT.

## QUICK START PROCEDURE

Demo circuit 2078A can be set up to evaluate the performance of the LTC6430-20. Refer to Figure 4 for proper equipment connections and follow the procedure below:

### Two-Tone Measurement:

Connect all test equipment as suggested in Figure 4.

1. The power labels of “VCC 4.75V-5.25V” and GND directly correspond to the power supply. Typical current consumption of the LTC6430-20 is about 170mA.
2. Apply two independent signals f1 and f2 from signal generator 1 and signal generator 2 at 600MHz and 601MHz, while setting the amplitude to  $-18\text{dBm}/\text{tone}$  at the demo board input (J1).
3. Monitor the output tone level on the spectrum analyzer. Adjust the signal generator levels such that the output power measures  $+1\text{dBm}/\text{tone}$  at the amplifier output J2, after correcting for external cable losses, minimum loss matching pads 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 599MHz and 602MHz, respectively. The measurement levels should be approximately  $-92\text{dBc}$ ;  $+47\text{dBm}$  is typical OIP3 performance for the LTC6430-20 at 600MHz.

The OIP3 calculation is:

$$\text{OIP3} = \text{POUT} + \Delta\text{IMD3}/2$$

Where:

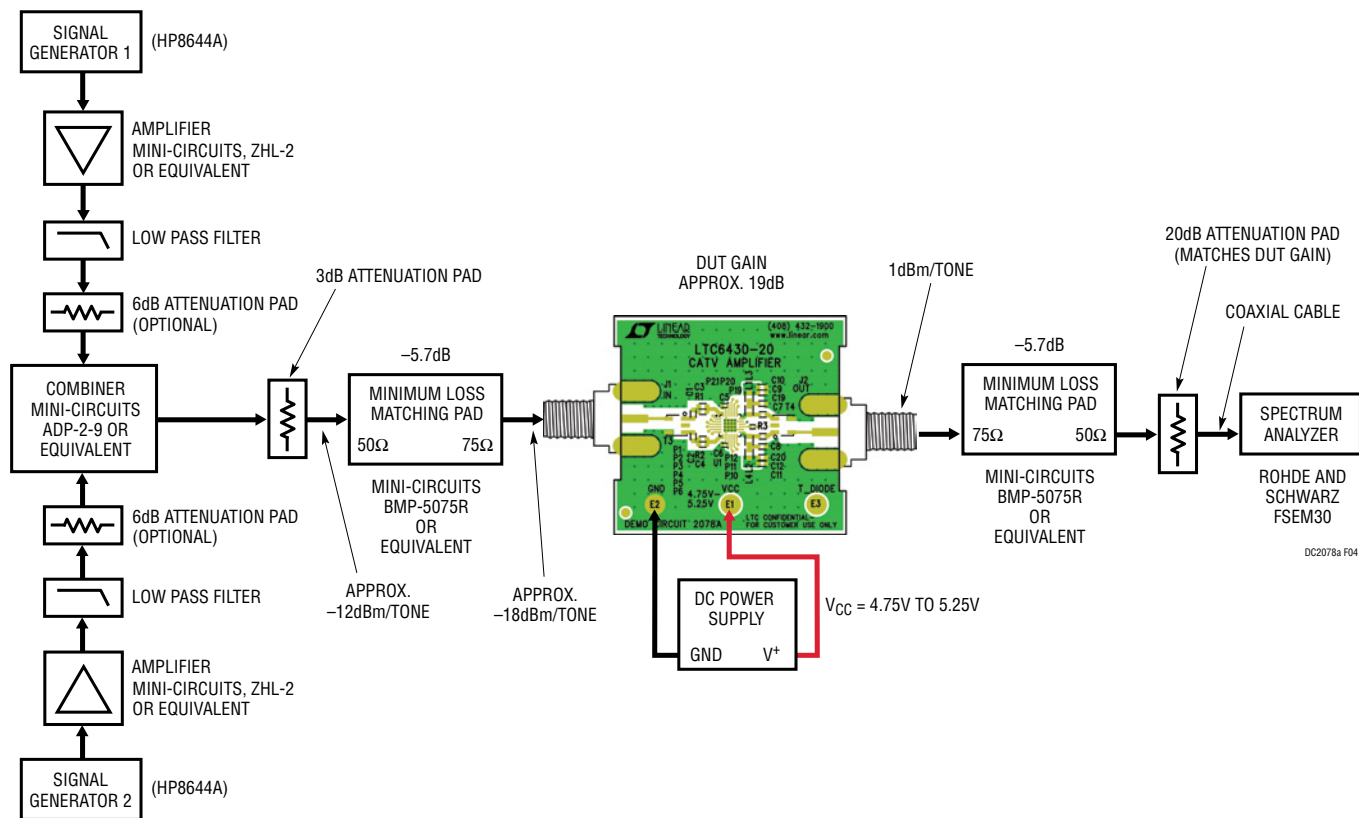
POUT is the lower output signal power of the fundamental products.

$\Delta\text{IMD3} = \text{POUT} - \text{PIM3}$ ; PIM3 is the higher Third-Order intermodulation product.

### Single-tone Measurement

5. Continue with step 4 above, turn off one signal source to measure gain and harmonic distortions.

**QUICK START PROCEDURE**



**Figure 4. Proper Equipment Setup for IP3 Measurement**

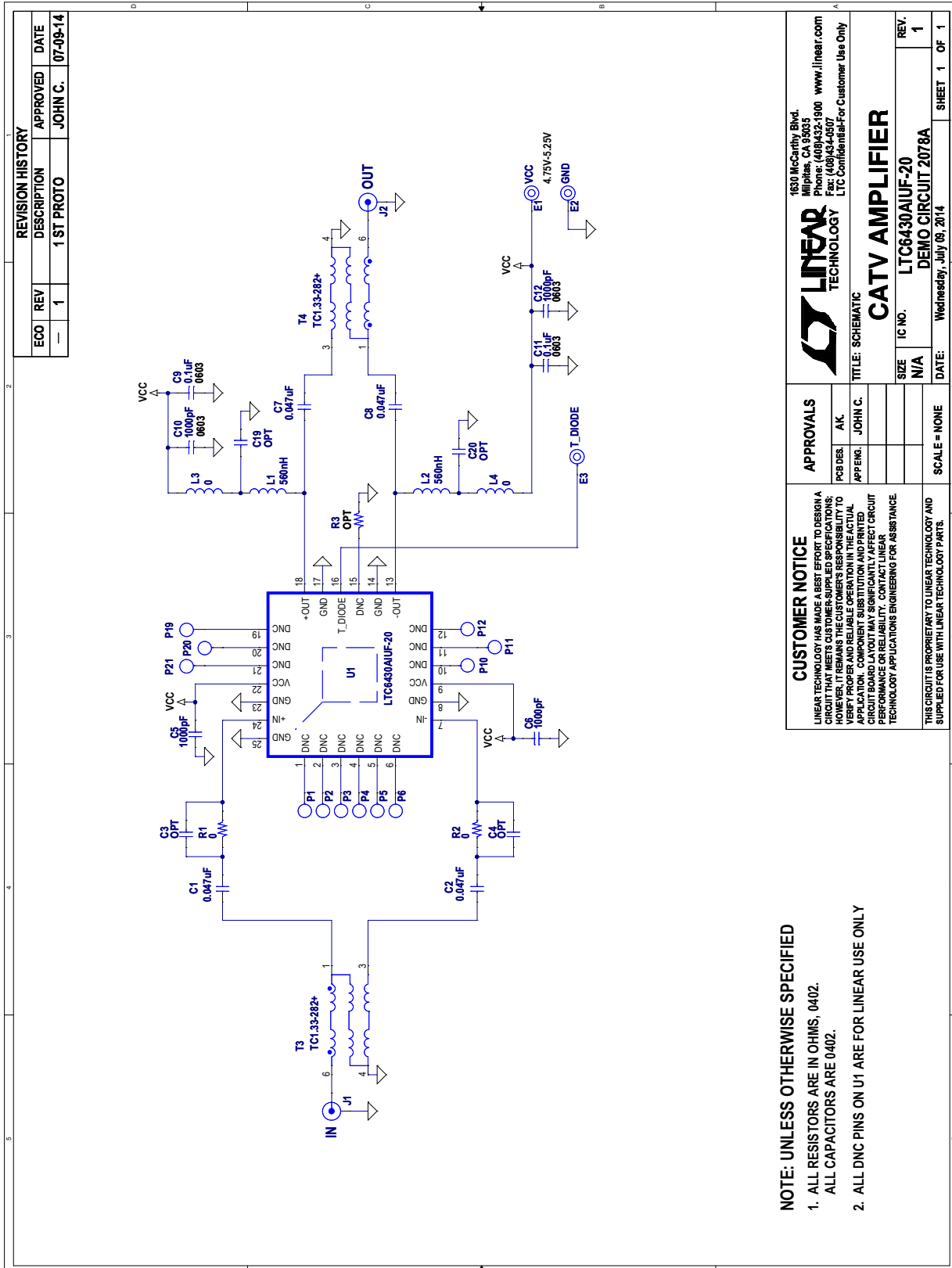
# DEMO MANUAL DC2078A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART #
1	4	C1, C2, C7,C8	CAP., X5R, 0.047 $\mu$ F, 25V 10%, 0603	AVX, 06033D473KAT2A
2	0	C3, C4, C19, C20	CAP., 0603, OPT	
3	2	C5, C6	CAP., X7R, 1000pF, 50V 5%, 0402	AVX, 04025C102JAT2A
4	2	C9, C11	CAP., X5R, 0.1 $\mu$ F, 10V, 10%, 0603	AVX, 0603ZD104KAT2A
5	2	C10, C12	CAP., X7R, 1000pF, 50V 5%, 0603	AVX, 06035C102JAT2A
6	3	E1, E2, E3	TESTPOINT, TURRET, 0.095"	MILL-MAX, 2501-2-00-80-00-00-07-0
7	2	J1, J2	F TYPE END LAUNCH JACK FOR 0.062" PCB, 75 $\Omega$	AMPHENOL CONNEX, 222181
8	2	L1, L2	INDUCTOR, CHIP, 560nH, 5%, 0603LS-1608	COILCRAFT, 0603LS-561XJLB
9	2	L3,L4	RES., CHIP, 0 $\Omega$ , 0603	VISHAY, CRCW06030000Z0ED
10	2	R1,R2	RES., CHIP, 0 $\Omega$ , 0603	VISHAY, CRCW06030000Z0ED
11	1	R3	R-0402, OPT	
12	2	T3, T4	RF TRANSFORMER TC1.33-282+, CASE STYLE: AT224-1	MINI-CIRCUITS, TC1.33-282+
13	1	U1	BALANCED AMPLIFIER LTC6430AIUF-20, QFN24UF-4X4	LINEAR TECH., LTC6430AIUF-20



**SCHEMATIC DIAGRAM**



**NOTE: UNLESS OTHERWISE SPECIFIED**

1. ALL RESISTORS ARE IN OHMS, 0402.  
ALL CAPACITORS ARE 0402.
2. ALL DNC PINS ON U1 ARE FOR LINEAR USE ONLY

# DEMO MANUAL DC2078A

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Mailing Address:

Linear Technology  
1630 McCarthy Blvd.  
Milpitas, CA 95035

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