DESIGN NOTES

Fast and Accurate 80MHz Amplifier Draws Only 2mA

Design Note 286

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Introduction

The 80MHz LT®1800 amplifier provides the high speed and DC accuracy required by low voltage signal conditioning and data acquisition systems while consuming a mere 2mA max supply current. The LT1800 operates with supplies from 2.4V to 12V and its rail-to-rail inputs and outputs allow the entire supply range to be used. DC performance is exceptional; the maximum offset voltage is only 350μV and the maximum input bias current is only 250nA. The amplifier is also available in dual and quad versions as the LT1801 and the LT1802, respectively. All are available in commercial and industrial temperature grades. The LT1800 is available in SO and SOT-23 packages, the LT1801 dual in an SO-8 package and the LT1802 quad in an SO-14 package.

Single Supply 1A Laser Driver

Figure 1 shows the LT1800 used in a 1A laser driver application. The LT1800 is well suited to this control task because its 2.4V operation ensures that it is awake at power-up and in control before the circuit can cause significant current to flow in the 2.1V threshold laser. Raising the noninverting input of the LT1800 causes its output to rise, turning on the FMMT619 high current NPN transistor and the SFH495 IR laser.

The transistor and laser turn on until the input voltage appears back at the LT1800 inverting input. This voltage therefore also appears across the 1Ω resistor R1. In order for this to occur, a current equal to $V_{IN}/R1$ must exist and the only place it can come from is through the laser. The overall circuit is thus a V-to-I converter with a 1A/V characteristic.

Lower values for R1 may be selected but the designer is reminded to keep series loop traces very short: for example, even 10nH of lead inductance causes a 16MHz pole into 1Ω and a 1.6MHz pole into 0.1Ω! Also when decreasing the value of R1, consider the total of the dynamic impedances of the transistor V_{BE} and the laser. They reduce the feedback voltage to R1 thus increasing circuit noise gain. This has the effect of degrading the DC precision and reducing the achievable bandwidth.

Frequency compensation components R2 and C1 are chosen for fast but zero overshoot time domain response which avoids overcurrent conditions in the laser. Their values may vary from design to design depending upon desired response characteristics, circuit layout, the value of R1 and the actual laser and transistor devices selected. Figure 2 shows the time domain response of this circuit, measured at R1 and given a 500mV 230ns input pulse. While the circuit shown is capable of 1A operation, the laser and the transistor are thermally limited and so must be operated at low duty cycles.

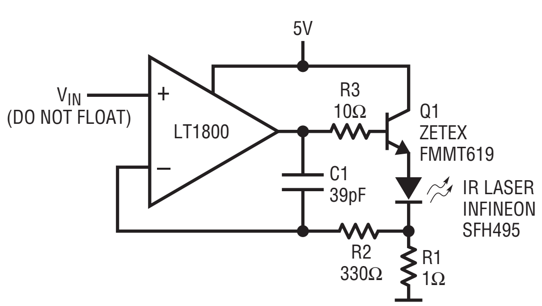


Figure 1. Small 1A Low Duty Cycle Laser Driver

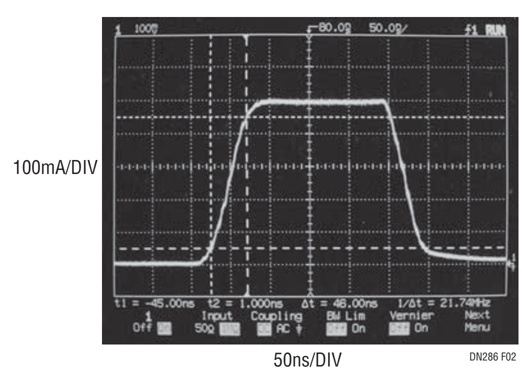


Figure 2. Pulse Response of 1A Laser Driver Circuit Shows Better Than 50ns Rise Time on 500mA Pulse

Low Power Amplifier with 250V Output Swing

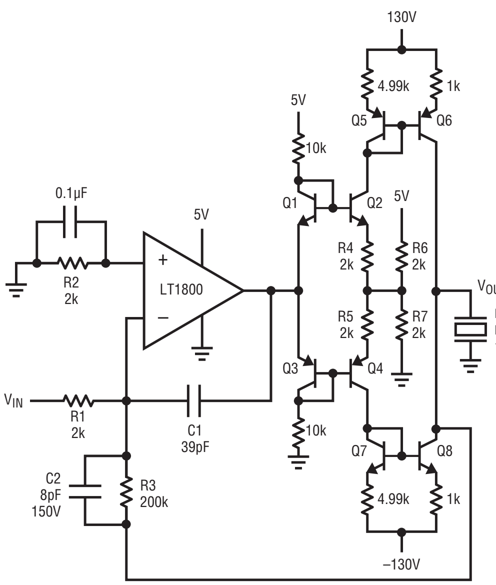
Some recently developed materials have optical characteristics that depend on the presence and strength of a DC electric field. Many applications require a bias voltage applied across such materials, sometimes as high as hundreds of volts, precisely in order to achieve and maintain desired properties in the material. The materials are not conductive and present an almost purely capacitive load.

Figure 3 shows the LT1800 used in an amplifier intended for capacitive loads and capable of 250V output swing. When no input signal is present, the op amp output sits at about mid-supply. Transistors Q1 and Q3 create bias voltages for Q2 and Q4 which are forced into a low quiescent current by degeneration resistors R4 and R5. When a transient signal arrives at V_{IN}, the op amp output jumps away from mid-supply and causes current through Q2 or Q4 depending on the signal polarity. The current, limited by the output swing of the LT1800 and the 3kΩ of total emitter degeneration, is level shifted to the high voltage supplies and mirrored into the capacitive load. This causes a voltage slew at V_{OUT} until the feedback loop (through R3) is satisfied.

The LT1800 output then returns back to near mid-supply, providing just enough DC output current to maintain the output voltage across R3. The circuit thus alternates between a low current hold state and a higher transient, but limited, current slew state.

Careful attention to current levels minimizes power dissipation allowing for a dense component layout, and also provides inherent output short-circuit protection. To further save power, the LT1800 is operated single supply with its inputs at ground. With the inputs at ground, the LT1800 turns off its internal bias current cancellation and adding R2 externally restores input precision.

Figure 4 shows the time domain response of the amplifier providing a ±100V output swing into a 100pF load.



$A_V = V_{OUT}/V_{IN} = -100$
±130V SUPPLY I_Q = 130A
OUTPUT SWING = ±128.8V
OUTPUT OFFSET ≅ 20mV
OUTPUT SHORT CIRCUIT CURRENT ≅ 3mA
10%–90% RISE TIME ≅ 8µs, 200V OUTPUT STEP
SMALL SIGNAL BANDWIDTH ≅ 150kHz
Q1, Q2, Q7, Q8: ON SEMI MPSA42
Q3, Q4, Q5, Q6: ON SEMI MPSA92

Figure 3. Low Power High Voltage Amplifier

Conclusion

The LT1800 and its LT1801 dual and LT1802 quad derivatives, provide low power solutions to high speed, low voltage signal conditioning. Rail-to-rail input and output maximize dynamic range and can simplify designs by eliminating the negative supply. Circuits that require source impedances of 1k or more, such as filters, benefit from the low input bias currents and low input offset voltage. The combination of speed, DC accuracy and low power makes the LT1800 a top choice for low voltage signal conditioning.

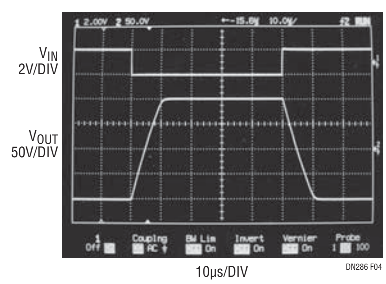


Figure 4. Large-Signal Time Domain Response of the Material Bias Amplifier

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