

DESIGN NOTES

Create a Virtual Ground with a Sink/Source Voltage Regulator

Design Note 115

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Analog signal processing functions embedded in dominantly digital systems usually require the addition of a negative power supply. Although many single supply analog components are available, optimum performance characteristics are often available only in devices that require both positive and negative power supplies. Even the use of single supply components does not solve all of the problems of single 5V operation of analog functions. Signal swings are restricted to a positive direction and may approach but not reach ground potential. The LT[®]1118-2.5 source/sink voltage regulator, used as a supply splitter, provides the designer with an alternative to adding a negative supply. Referencing the signal levels to the regulator's 2.5V output allows symmetrical signal swings and also allows the selection of op amps, active filters and other components that do not have common mode range to ground.

Resistive dividers are frequently used as supply splitters to establish a virtual ground. This approach is often effective, but the circuit designer must work around the resistive divider's severe performance limitations. A fundamental limitation of a resistive divider is the high power dissipation required to obtain any suitable output impedance. A divider made from 240 Ω resistors, as in Figure 1a, pulls over 10mA of quiescent current and has a DC output impedance of 120 Ω . In contrast, the LT1118-2.5 splitter shown in Figure 1b achieves an output impedance of less than 0.025 Ω with a quiescent current of 600 μ A. The resistive divider's high output impedance restricts its use to high impedance, low frequency signal sources; otherwise, the output impedance

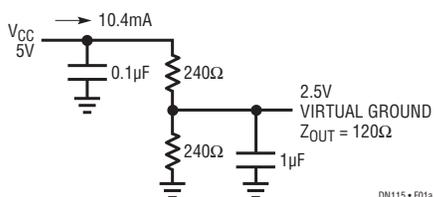


Figure 1a. Resistive Divider Supply Splitter

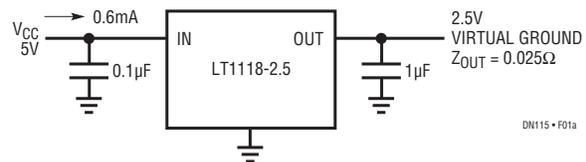


Figure 1b. LT1118-2.5 Supply Splitter

of the splitter will cause gain errors and AC response degradation in all op amp configurations except unity-gain buffers. Use of large feedback network resistors will limit frequency response and noise performance.

Figure 2 shows the LT1118-2.5 output impedance vs frequency for several output current loads. Examination of this plot reveals several operating characteristics of the regulator. At low frequencies, the output impedance is below 0.025 Ω at all operating points. No passive divider can approach this low impedance. The quiescent current condition has the maximum impedance, with both sink or source current loads causing further output impedance reduction. This level of impedance variation is so low however, that no measurable distortion is introduced in the signal. The low output impedance also allows low feedback resistance video amplifiers

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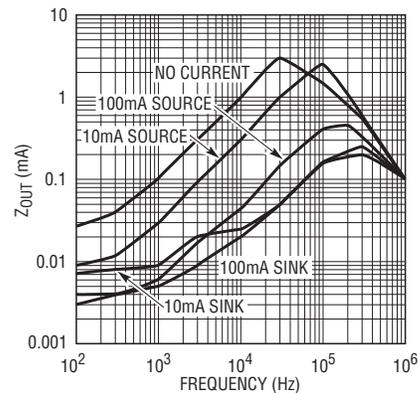


Figure 2. LT1118-2.5 Output Impedance vs Frequency

to operate from the virtual ground without gain errors or distortion. As frequencies increase, the output impedance of the regulator increases, until the output capacitor's impedance dominates and rolls the impedance off to lower values again. With the 1 μ F capacitor used in this example, maximum output impedance is 3 Ω at 30kHz. Larger output capacitors will reduce this maximum impedance by intersecting the regulator's output impedance curve at lower frequencies. Only in the most demanding applications should a larger capacitor be required.

The LT1118 family of regulators are all capable of sourcing 800mA and sinking 400mA of load current. This high level of current will handle almost any signal levels encountered in supply splitter applications. Figure 3 shows the fast (less than 5 μ s) load transient settling characteristics of the LT1118-2.5. This response was obtained using a 1 μ F output capacitor with 800mA to -400mA load steps. The regulator is stable with any output capacitance greater than 0.2 μ F, with larger capacitance reducing the output voltage transient

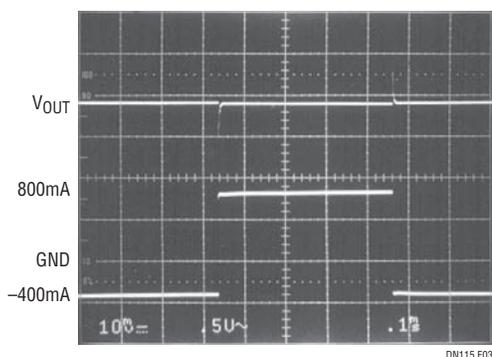


Figure 3. LT1118-2.5 Load Transient Response

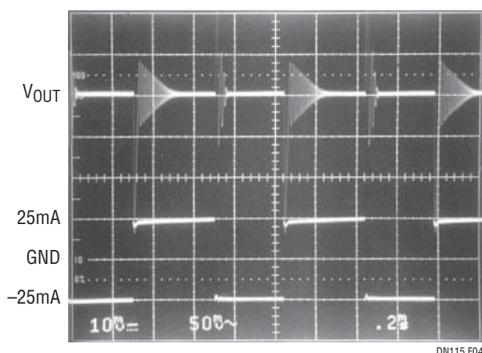


Figure 4. Competitor's Supply Splitter Load Transient

amplitude. Competing supply splitter circuits do not exhibit well-behaved transient behavior. This is illustrated in Figure 4, which shows a competitor's load transient response from -25mA to 25mA, the circuit's full output capability. With 1 μ F of output capacitance the regulator is almost unstable.

The LT1118-2.5, like the LT1118-2.85/LT1118-5, is offered in both SOT-223 and SO-8 packages. The SO-8 version includes a Shutdown pin, which turns the output high impedance and drops supply current to zero. The SO-8 versions can be used to minimize power consumption when the analog functions are not in use. All members of the LT1118 family share the performance features of fast settling and excellent transient response for loads between 400mA sinking to 800mA sourcing.

The LT1118-5 is a useful regulator for applications requiring very fast settling to full load transients. The current sinking output limits output voltage overshoot compared to conventional regulators.

The LT1118-2.85 is an ideal choice for SCSI terminator applications. The increasing use of active negation drivers to improve noise immunity in fast SCSI systems causes conventional voltage regulators to lose regulation. The current sinking output mode of the LT1118-2.85 maintains a solid 2.85V output with the maximum 24 of 27 data lines negated. The use of one LT1118-2.85 and twenty-seven 110 Ω surface mount resistors provides a more economical, higher performance solution for terminating fast wide SCSI data busses than SCSI terminators with on-chip resistors. Terminators with on-chip resistors have serious deficiencies in power dissipation and output capacitance compared to an LT1118-2.85 solution. Up to 3.5W of power is dissipated terminating a 27-line SCSI bus. Terminators with on-chip resistors cannot dissipate this much power from a surface mount IC package, so multiple chips must be used to terminate the entire bus. One LT1118-2.85 with external resistors can do the whole job, since 2W is dissipated in the resistors and only 1.5W in the IC. The LT1118-2.85 plus external resistors also provides better noise immunity than terminators with on-chip resistors. The pin capacitance of the IC can be as high as 2pF. Capacitance on the SCSI data lines causes reflections and loss of noise immunity at high data rates. With the LT1118-2.85 plus external resistor solution, the data line capacitance is minimized to the PC board stray capacitance.

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