APPLICATION NOTE 1803

Simple Circuit Provides +5V Gate Bias from -48V Input

Dec 05, 2002

Abstract: In this design idea a small circuit with six components derives 5V gate bias from the -48V rail widely used in telecom applications. The MAX6138 shunt voltage reference and the MAX1683 charge pump are featured in the design.

A similar version of this article appeared in the September 19, 2002 issue of EDN magazine.

A small and simple circuit (Figure 1) derives +5V from the -48V rail widely used in telecom applications. Useful for gate bias and other purposes, the 5V supply delivers up to 5mA. A shunt reference (U1) defines -5V as ground reference for a charge pump (U2), and the charge pump doubles this 5V difference (between system ground and charge pump ground) to produce +5V with respect to the system ground.

The shunt reference maintains 5V across its terminals by regulating its own current (I_S), which in turn is determined by the value of R. Current through R (I_R) is fairly constant, and varies only with the input voltage. I_R, the sum of the charge-pump and shunt-reference currents (I_R = I_CP + I_S), has maximum and minimum values set by the shunt reference.

The shunt reference sinks up to 15mA, and requires 60µA minimum to maintain regulation. Maximum I_R
is determined by the maximum input voltage. To prevent excessive current in the shunt reference with no load on the charge-pump output, use the maximum input voltage (-48V - 10% = -52.8V) when calculating the minimum value of R. The maximum reference sink current (15mA) plus the charge pump’s no-load operating current (230µA) equals the maximum IR value (15.23mA). Thus,

\[ R_{\text{MIN}} = \frac{(V_{\text{IN(MAX)}} - V_{\text{REF}})}{I_{R(MAX)}} = \frac{(52.8V - 5V)}{0.01523A} = 3.14k\Omega. \]

Choose the next-highest standard 1% value, which is 3.16kΩ.

Guaranteed output current for the charge pump is calculated at the minimum line voltage: -48V + 10% = -43.2V. The charge pump’s maximum input current is:

\[ I_{\text{CP}} = \frac{(V_{\text{IN(MIN)}} - V_{\text{REF}})}{R} - I_{\text{SH(MIN)}} = \frac{(43.2V - 5V)}{3.16k\Omega} - 90\mu\text{A} = 12\text{mA}, \]

where 90µA is the minimum recommended operating current for the shunt reference. Assuming 90% efficiency in the charge pump, the output current is

\[ I_{\text{OUT}} = \frac{I_{\text{CP}}}{2} \times 0.9 = \frac{(12\text{mA}/2) \times 0.9}{2} = 5.4\text{mA}. \]

Charge-pump input current is halved, because output voltage is twice the input voltage. Power is dissipated via the shunt reference under no-load conditions, so be sure that R can handle the resulting wattage. A 1W resistor suffices in this case.

<table>
<thead>
<tr>
<th>Related Parts</th>
<th>Free Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX1683</td>
<td>Switched-Capacitor Voltage Doublers</td>
</tr>
<tr>
<td>MAX6138</td>
<td>0.1%, 25ppm, SC70 Shunt Voltage Reference with Multiple Reverse Breakdown Voltages</td>
</tr>
</tbody>
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