Designing a stable bipolar supply for powering op-amps, multiplexers, switches, etc. can be difficult, especially if the two voltages must track each other with respect to a non-zero or adjustable reference level. Such a regulated supply for low-power applications (Figure 1) produces a main-controller output voltage (V_MAIN) and two tracking voltages symmetric about an adjustable reference voltage (V_REF). You create the circuit by adding four Schottky diodes (D2–D5) and two flying capacitors (C2–C3) to the basic boost-converter circuit for U1.

![Figure 1](image)

**Figure 1.** This single-IC circuit generates the bipolar voltages required in many industrial analog applications, as well as contrast-control voltages for an STN LCD.

U1 is an efficient, single-output boost converter for applications requiring outputs up to 36V and a wide input-voltage range (3V to 11V). U1 requires no external switching devices and draws a typical supply current of only 350µA, making it ideal for handheld and point-load applications. It is characterized for loads up to 120mW.

The ±30V outputs are centered about a reference level of V_REF = 0V (Figure 2). For balanced loads of
0.5mA to 2mA, tracking is excellent over a wide input range. Figure 3 shows how $\pm V_{\text{OUT}}$ and $-V_{\text{OUT}}$ track each other as $V_{\text{REF}}$ is moved away from 0V. One example of the need for a non-zero $V_{\text{REF}}$ is indicated in Figure 4, in which the LCD-contrast voltages must be symmetric about $V_{\text{REF}}$ to avoid a DC component across the liquid crystal, which in turn can damage the LCD or shorten its life.

Figure 2. This graph shows the Figure 2 outputs of $\pm V_{\text{OUT}}$ and $V_{\text{MAIN}}$ across the full 3V–11V input voltage range, under varying load conditions.

Figure 3. This graph shows that the $\pm V_{\text{OUT}}$ outputs in Figure 1 track each other with respect to changes in the reference voltage: $\pm V_{\text{OUT}} = V_{\text{REF}} \pm V_{\text{MAIN}}$. 
Figure 4. To avoid a damaging DC component across the LCD, these contrast waveforms are symmetrical about the reference level $V_{REF}$.

A FET internal to U1 repeatedly connects LX (pin 6) to ground and then releases it, causing the LX voltage to toggle between ground and $V_{MAIN}$ plus one diode drop ($D1$). That action generates the $\pm V_{OUT}$ voltages as follows:

$\text{-VOUT output, phase 1:}$ The rise of LX voltage to $V_{OUT} + V_{DIODE}$ forces voltage on the other side of C3 to $V_{REF} + V_{DIODE}$, creating a differential of $V_{MAIN} - V_{REF}$ across C3. The LX node is our reference point. Phase 2: As LX is switched to ground, the load side ($-V_{OUT}$) sees $-V_{MAIN} + V_{REF}$, forcing current from the $-V_{OUT}$ load through $D5$, and the cycle repeats itself. Note that $+V_{OUT}$ and $-V_{OUT}$ develop on alternate phases. The resulting $-V_{OUT}$ voltage is

$$-V_{OUT} = -V_{MAIN} + V_{REF} + V_{DIODE}.$$  

$\text{+VOUT output, phase 2:}$ When LX is switched to ground, the load side of C2 sees $V_{REF} - V_{DIODE}$. Then, (phase 1) the rise of LX to $V_{MAIN} + V_{DIODE}$ forces a voltage of $V_{MAIN} + V_{REF}$ on the other side of C2. The resulting $+V_{OUT}$ voltage is:

$$+V_{OUT} = V_{MAIN} + V_{REF} - V_{DIODE}.$$  

These load equations suggest, and Figures 2 and 3 illustrate, that $-V_{OUT}$ and $+V_{OUT}$ track each other with respect to $V_{MAIN}$, and are offset by one diode drop from $V_{REF}$. $D1$–$D5$ are low-current Schottky diodes. $C2$ and $C3$ can be ceramic capacitors in the range 1nF to 100nF, preferably with voltage ratings of approximately $2 \times |V_{OUT}|$. Larger values of $C2$ and $C3$ provide more stable outputs under a wide range of load currents. $L1$ is typically 47$\mu$H, and the output capacitors $C4$–$C6$ (shown with 1$\mu$F values).
may be sized according to the allowable output ripple.

A similar version of this article appeared in the July 15, 2002 issue of Planet Analog magazine.

**Related Parts**

| MAX5026      | 500kHz, 36V Output, SOT23, PWM Step-Up DC-DC Converters | Free Samples |

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