# Generate negative output voltages from a positive input voltage

**Industrial control equipment such as PLCs (programmable logic controllers), I/O modules, mass flow controllers, and other industrial systems need to process analogue signals in order to accomplish their intended function, explain, Dipankar Mitra and Ramesh Giri, Maxim Integrated.**

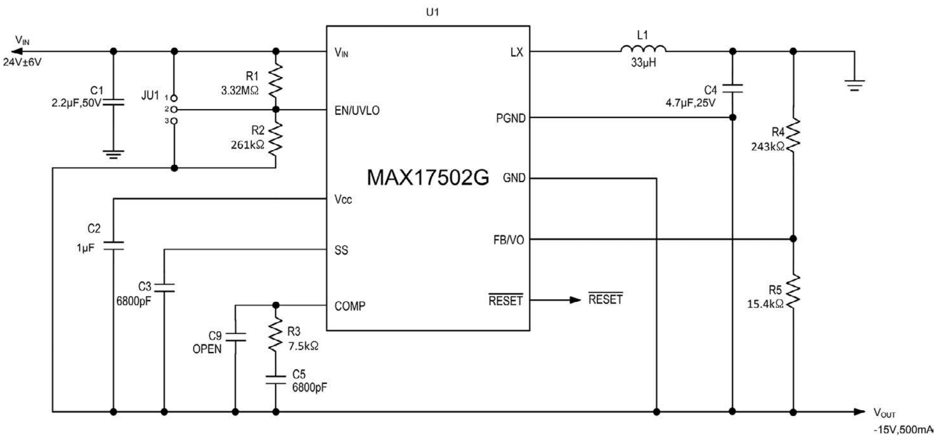


Figure 1: Schematic for a +18V to +30V/-15V positive-to-negative output voltage converter using the MAX17502.

Typically these analogue signal-processing circuits require both positive and negative supply voltages such as ±5, ±12, ±15V generated from a 24V DC bus.

High-voltage synchronous step-down converters with integrated MOSFETs offer a compact, high-efficiency to generate the positive output voltage rail. The same synchronous step-down converters can be used to also generate negative output voltage rails. Using these techniques the system designer can generate both rails using the same device, thus reducing the number of parts to stock. A -15V output voltage application demonstrates how this can be done, using the MAX17502 synchronous step-down converter as an example.

## Operating principle

Figure 1 shows the schematic of a MAX17502 synchronous step-down converter configured as a synchronous inverting buck-boost converter.

The operating principle behind this circuit can be understood by examining Figure 2 and Figure 3 which illustrate the step-down converter and inverting buck-boost converter. The configuration of switches S1, S2 and filter components Lo and Co is identical. The difference between the two configurations lies in the terminal voltages that are defined as input and output voltages of the converter.

In the step-down converter of Figure 2, the terminal voltage VAC is defined as the input

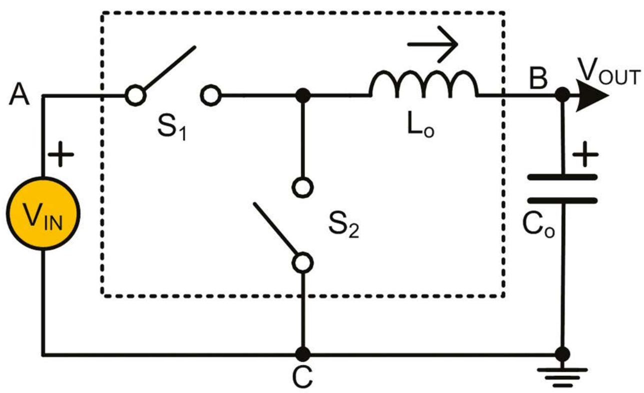


Figure 2: Simplified schematic of the synchronous step-down converter.

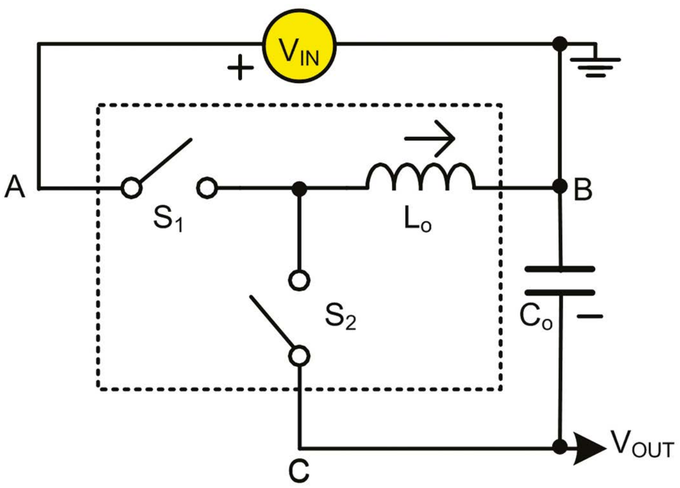


Figure 3: Simplified schematic of the synchronous inverting buck-boost converter.

voltage (VIN) and output is obtained at the terminal voltage VBC (VOUT). Switch S1 turns ON and uses VAC to store energy in the inductor Lo, while also delivering energy to the output capacitor Co. Then S1 turns OFF, at which point S2 is closed, to continue delivering energy stored in Lo to the output capacitor Co. Since the terminal C is defined as the ground of this circuit, VBC is obtained as a positive voltage with respect to the ground terminal C.

In the inverting buck-boost converter of Figure 3, the terminal voltage VAB is defined as the input voltage (VIN), and output is obtained at the terminal voltage VCB (VOUT). Switch S1 turns ON and uses VAB to store energy in the inductor Lo. Then S1 turns OFF, at which point S2 is closed, to continue delivering energy stored in Lo to the output capacitor Co.

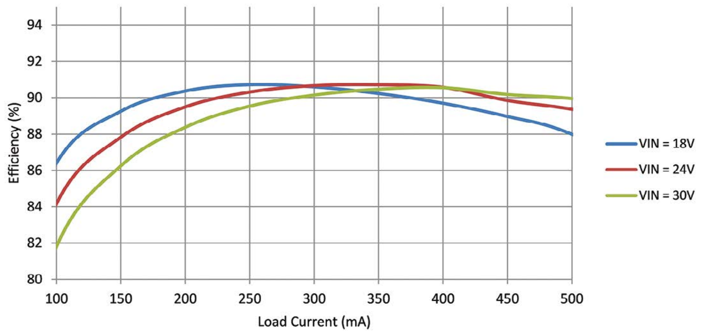


Figure 4: Efficiency vs. load current.

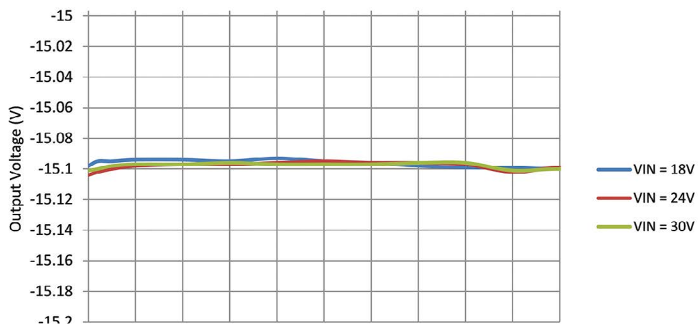


Figure 5: Load and line regulation of output voltage

Since the terminal B is defined as the ground of this circuit, VCB is obtained as a negative voltage with respect to the ground terminal B. In general, in the absence of other IC design constraints, a synchronous step-down converter can be employed as an inverting buck-boost converter.

## Power-supply specifications

The requirements for the example power supply of Figure 1 are operating input voltage (VIN): 24V ±6V; an output voltage (VOUT) of -15V; an output current (IOUT), maximum of 500mA; a steady-state input ripple voltage (VIN_RIPPLE) of 1% of nominal VIN and a steady-state output ripple voltage (VOUT_RIPPLE) which is 1% of nominal VOUT

Figure 4, left, shows the efficiency versus load current performance for the Max17502G-based inverting synchronous buck-boost converter.

The buck-boost converter is available in a 10pin, 3 x 2mm TDFN and 14pin 5 x 4.4mm TSSOPs with an industrial operating temperature range of -40 to +125ºC. As well as industrial process control, the converter can be used in automotive, basestation, VOIP and telecomms equipment as well as HVAC and building control.

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