Boost Supply and High-Voltage DAC Provide Tuning Signal for Antennas and Filters

By Ken Kavanagh

Antenna arrays and filters are often tuned by varying the voltage on a barium strontium titanate (BST) capacitor. When this ferroelectric material is used in capacitors, an applied voltage causes a small variation in the crystal structure, which changes the dielectric constant and, therefore, the capacitance. Electronically tunable BST capacitors can handle higher power and larger signal amplitude than the conventional varactor diodes.

In typical applications, the tuning capacitor compensates for component tolerance, adjusts the cutoff frequency of a filter, or matches the network impedance of a tunable antenna. The BST capacitor is tuned by applying a voltage between 0 V and 30 V. As power supplies in modern electronic devices trend toward lower voltages, 3.3-V, 2.5-V, or even 1.8-V supplies are common, especially in battery-powered applications. Despite the benefits of tuning, it does not always make sense to add a separate high-voltage supply for this function alone. Thus, a convenient way to generate the power supply is required.

In this application, for example, a 3-V power supply is available, but the BST capacitors require voltages in excess of 20 V for full control. The two main circuit blocks are the ADP1613 step-up switching converter and the AD5504 high-voltage DAC. The circuit shown in Figure 1 generates DAC output voltages up to 30 V. The DAC outputs set the bias voltages for the BST capacitors, thus adjusting the antenna response.

The AD1613 step-up dc-to-dc switching converter (Figure 4) integrates a power switch capable of providing an output as high as 20 V. Higher voltages can be achieved by using external components. As shown, the ADP1613 generates a 32-V output from a 3-V input. The ADIsimPower™ tool[1] provides an easy way for designers to determine the appropriate components based on the input requirements.

The 32-V output from the ADP1613 powers the AD5504 quad, 12-bit, high-voltage DAC (Figure 5), which can provide up to 60 V on each of its four outputs. The voltage on the $\overline{R\_SEL}$ pin determines its full-scale output. In this application, $\overline{R\_SEL}$ is connected to V_{DD}, setting the full-scale output to 30 V. The DAC registers are updated via the 3-V compatible serial interface. All four DACs are updated simultaneously by pulsing the load pin ($\overline{LDAC}$) low, thus allowing four BST capacitances to be changed at the same time.

Figure 2 shows the equivalent circuit of a BST capacitor used as a tunable matching network. Figure 3 shows the transfer function of the BST capacitance vs. voltage and the antenna response. BST capacitors can be obtained from suppliers such as Agile RF.[2]
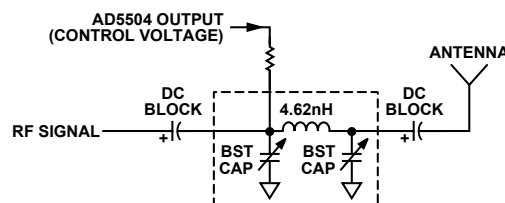

Figure 2. BST capacitor equivalent circuit.

Circuits such as that of Figure 1 can benefit next-generation mobile phones, which are being pressured by two opposing forces. On one side is the ever-present requirement to reduce size and power consumption. On the other is the need to increase performance, utilizing more frequency bands by inserting more antennas and radio systems into a smaller volume. Antenna designers are reaching physical design limits with regard to volume and efficiency, as decreasing antenna volume decreases efficiency. Tunable antennas solve this problem in multiband, multimode phones and can extend the operating frequency range of a cell phone, switching from US GSM850 to European GSM900, for example, while maintaining size and efficiency. In multiuse devices, different head and hand positions used while texting, talking, or surfing the Web present the antenna with different load impedances, detuning the antenna and decreasing signal quality. A tunable impedance matching network can adapt for these varying conditions and recover the detuned signals.
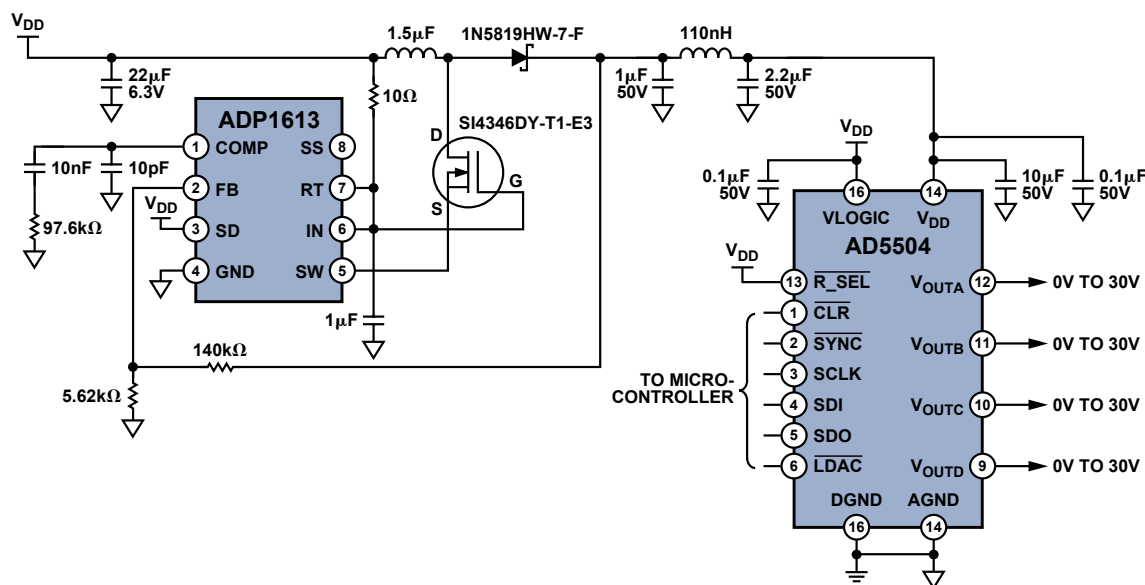

Figure 1. Boost supply and high-voltage DAC provide tuning signal for BST capacitors.

Step-Up DC-to-DC Switching Converter Operates at 650 kHz/1300 kHz

The ADP1613 step-up converter is capable of supplying over 150 mA at voltages as high as 20 V, while operating with a single 2.5-V to 5.5-V supply. Integrating a 2-A, 0.13-Ω power switch with a current-mode, pulse-width modulated regulator, its output varies less than 1% with changes in input voltage, load current, and temperature. The operating frequency is pin-selectable and can be optimized for high efficiency or minimum external component size: at 650 kHz it provides 90% efficiency; at 1.3 MHz its circuit implementation occupies the smallest space, making it ideal for space-constrained environments in portable devices and liquid-crystal displays. The adjustable soft-start circuit minimizes inrush currents, ensuring safe, predictable start-up conditions. The ADP1613 consumes 2.2 mA in the switching state, 700 μA in the nonswitching state, and 10 nA in shutdown mode. Available in an 8-lead MSOP package, it is specified from −40°C to +85°C and priced at $0.70 in 1000s.

Quad, 12-Bit DACs Provide High-Voltage Outputs

The AD5504 quad, 12-bit, high-voltage DAC has pin-selectable output ranges of 0 V to 30 V and 0 V to 60 V. Functionally complete, it includes a precision voltage reference, temperature sensor, four double-buffered DACs, and four high-voltage amplifiers. Upon power-up, the digital section is enabled and set to a known state; the analog section remains disabled until a power-up command is issued via the SPI port. The temperature sensor disconnects the analog outputs and sets an alarm flag if the die temperature exceeds 110°C. The AD5504 specifies 1 LSB max differential nonlinearity (DNL) and 3-LSB max integral nonlinearity (INL) in 30 V mode. Operating on 10-V to 62-V and 2.3-V to 5.5-V supplies, it consumes 2 mA in *normal* mode and 30 μA in *power-down* mode. Available in a 16-lead TSSOP package, it is specified from −40°C to +105°C and priced at $9.92 in 1000s.

References
(Information on all ADI components can be found at www.analog.com.)
[1]www.analog.com/adisimpower.
[2]www.agilerf.com.

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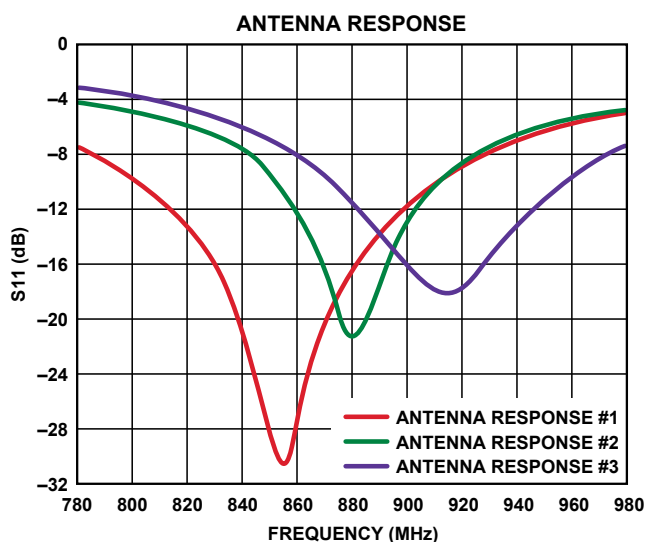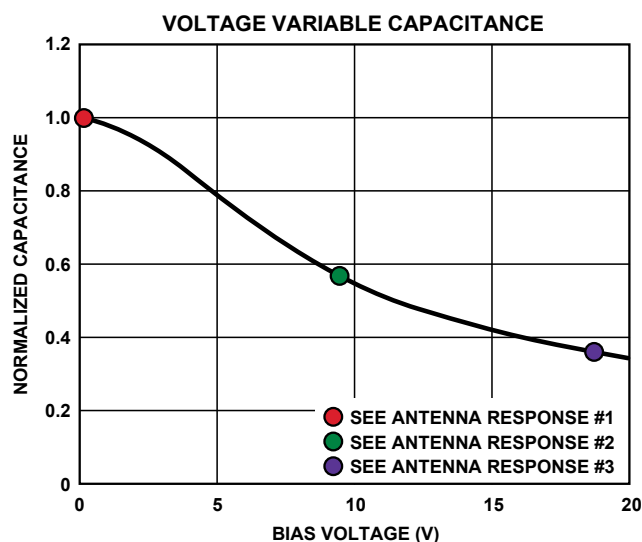
Figure 3. Bias voltage vs. BST capacitance; resulting antenna response.
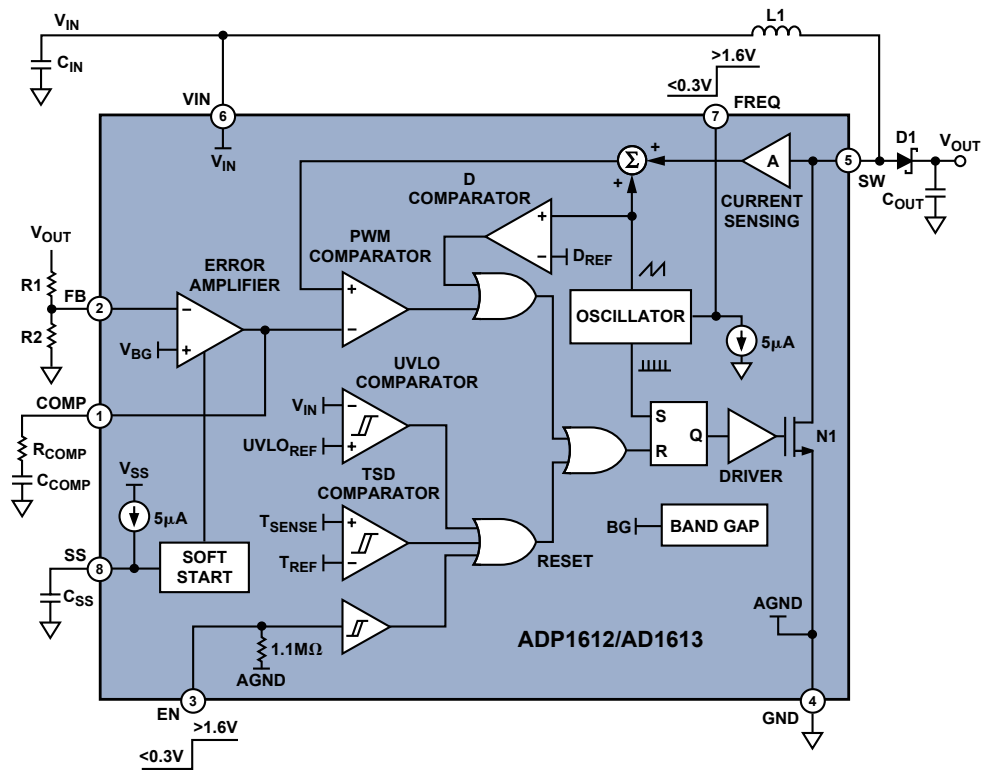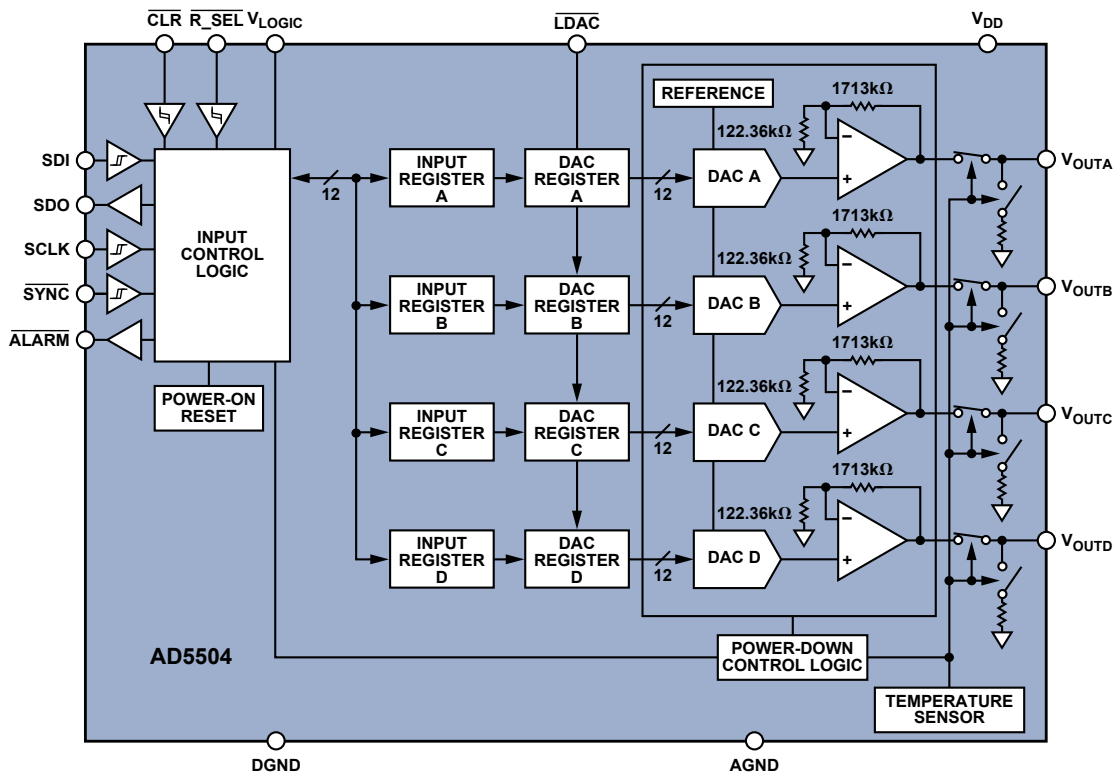
Figure 4. ADP1613 functional block diagram.

Figure 5. AD5504 functional block diagram.