AN3456
Rev 0, 04/2007

Generating a Supply Rail for the MC34940 and MC33941 in Low Voltage Systems

This application note demonstrates how to generate the supply voltage required by Freescale's MC34940 and MC33941 Electric Field Imaging Devices in low voltage systems that do not have an appropriate voltage available. Inductive boost and regulated charge pump techniques are compared and example circuits are given using off-the-shelf components.

The MC34940/33941 is an Electric Field Imaging Device used in cost-sensitive applications where non-contact sensing of objects is desired. The MC34940 generates a typically 120 kHz, low distortion sine wave, which is detected on its seven electrode inputs that are connected to external sense electrodes. Changes in external electrical conductance on the external electrodes are measured by the MC34940/33941. Common applications for the MC34940/33941 are user interface touch panels and liquid presence and level detection.

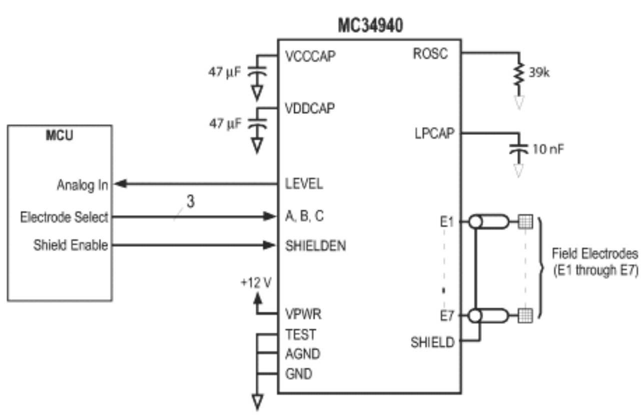

Figure 1. MC34940/33941 in a System

The MC34940/33941's power supply requirement is a nominal 12 V (9 V minimum) at 7 mA (8 mA maximum). This input supply is internally regulated down to a clean 8.5 V analog supply and 5 V digital supply. The difference between the MC34940 and the MC33941 is that the internal 5 V regulator in the MC33941 is guaranteed to deliver 5 V ±5% into external loads up to 75 mA. The rather unusual 8.5 V is used for the sine wave generation circuitry, which provides a 5 V peak-to-peak sine wave. This healthy swing is one of the reasons the MC34940/33941 exhibits great sensitivity, and because the drive waveform is a pure sine wave with negligible harmonics, the connected electrodes do not become a source of EMI themselves.

So, having explained why the MC34940/33941 requires a 9 V minimum supply, let's get on to the purpose of this article: how do you get this voltage in a system with only a low voltage battery, 3.3 V supply, or a 5 V supply? Two common techniques exist to do this: the use of a charge pump or the use of a boost converter. A charge pump, at its simplest, charges an input capacitor up to the input supply voltage and then discharges itself into an output capacitor. This cycle repeats as a continuous process. In the charging part of the cycle, the input capacitor is connected directly across the input supply, so it charges up the input supply voltage. The sneaky part is during the discharge when the negative end of the input capacitor is disconnected from the negative side of the input supply (i.e., 0 V) and connected to the positive end of the output capacitor. At the same time, the positive end is disconnected from the positive side of the input supply and connected to the positive end of the output capacitor. SInce the input capacitor is charged up to the supply voltage, the positive end of the input capacitor is now effectively at twice the supply voltage relative to 0 V. There is a voltage doubling process. The input capacitor is commonly described as a flying capacitor because both ends are switched to different nodes during each half of the process.

A simple voltage doubler, such as the common ICL7660 will give an unloaded output of twice the input supply. With a 5 V ±5% supply, the output is 9.5 V to 10.5 V unloaded. Unfortunately, when loaded, the output drops below the MC34940/33941's 9 V minimum with a toleranced 5 V supply. Enter Linear Technology's LTC1262, which takes a 4.75 V to 5.5 V input supply and generates a 12 V output good for 30 mA. This part works by charging up two flying capacitors (C2 and C3 in Figure 2) in parallel to the input voltage, then putting them in series on top of the input supply to discharge a nominal 15 V into output capacitor C4. The part regulates the output to 12 V by skipping power conversion (charge/discharge) cycles when the output is at the desired 12 V.

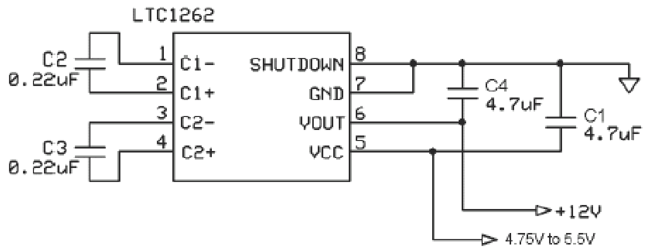

Figure 2. LTC1262 Charge Pump

The LTC1262 is a good solution for systems with a 5 V supply, but what about lower voltage systems? Here we have to turn to boost converters with an inductor. Boost converters work by ramping up current from the input supply through an inductor and power switch to ground, then turning off the switch. An output diode steers the inductor current to an output capacitor where the energy is stored as the cycle repeats. There are many suitable low cost boost converters that can be used, and the trick is to pick one that is not rated at an unnecessarily higher output than is needed. Picking a boost converter that is just good enough means that the inductor, diode, and capacitor peak current ratings are low and cheap. The ON Semiconductor NCP1403SNT1, shown in Figure 3, happily delivers the MC34940/33941's worst-case requirement of 8 mA from an input voltage of below 2 V. This circuit is suitable for 2-cell, 3-cell and single Li-ION powered applications, as well as from nominal 3 V and 5 V rails. The NCP1403SNT1 comes in a small SOT23-5 package as does the BAR43C dual-diode. The capacitors can be surface mount ceramic and the TDK sourced inductor is only 4.8 mm long by 3.4 mm wide.

The circuit in Figure 3 regulates its output at a nominal 9.7 V which is set by resistors R1 and R2. This is comfortably above the 9 V minimum required by the MC34940/33941, but not unnecessarily high to waste system power. The output voltage with an 8 mA load on the prototype varied from 9.8 V with a 5 V input supply down to 9.57 V with input down at 2 V.

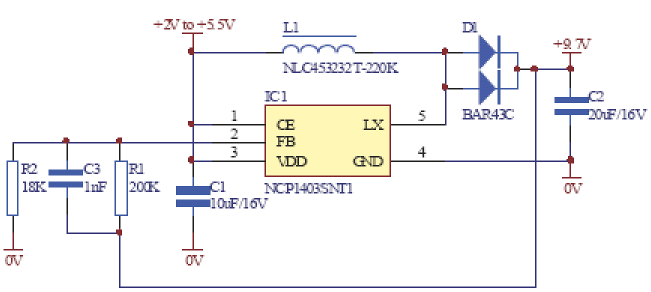

Figure 3. NCP1403SNT1 Boost Converter

POWERING EXTERNAL CIRCUITS FROM THE MC34940/33941'S +5 V OUTPUT

The MC34940/33941's internal 5 V regulator will also supply 5 V into external loads up to 75 mA. This regulated output may be useful in low voltage systems (powered by sources such as dual AA cells, or a single Li-ION cell) which needs 5 V for other parts of the system. Simple boost converters with internal current limits, such as the NCP1402SNT1, have reducing output current capability as input voltage reduces. This is shown in Figure 4. This means that the available extra current from the MC34940/33941's 5 V output is dependent on your minimum supply voltage to the NCP1402SNT1. For example, a Li-ION battery with a 3 V minimum voltage will allow you to draw 24 mA from the MC34940/33941's 5 V output

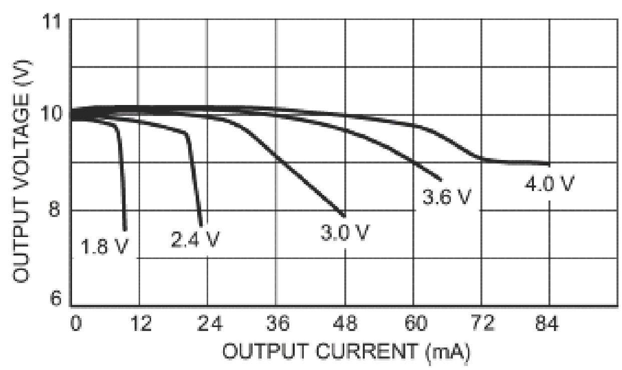

Figure 4. NCP1403SNT1 Output Current vs. Input Voltage

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Rev. 0
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